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(54) **VARIABLE VALVE MECHANISM, ENGINE,
AND AUTOMATIC TWO-WHEELED
VEHICLE**

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See application file for complete search history.

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F01L 1/18 (2006.01)

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(57) **ABSTRACT**

The present invention is capable of more smoothly changing a phase of a cam shaft in a rotation direction. A variable valve mechanism changes an opening/closing timing of an intake valve or an exhaust valve in response to an engine rotation speed. The variable valve mechanism includes: a cam sprocket which rotates in response to a rotation of a crank shaft; an intake cam shaft which is integrated with an intake cam and is provided to be rotatable relatively to the cam sprocket; and a link member that transmits a rotation from the cam sprocket to the intake cam shaft. The link member is supported by the cam sprocket to be swingable and swings in response to a change in rotation speed of the cam sprocket to rotate the intake cam shaft relatively to the cam sprocket.

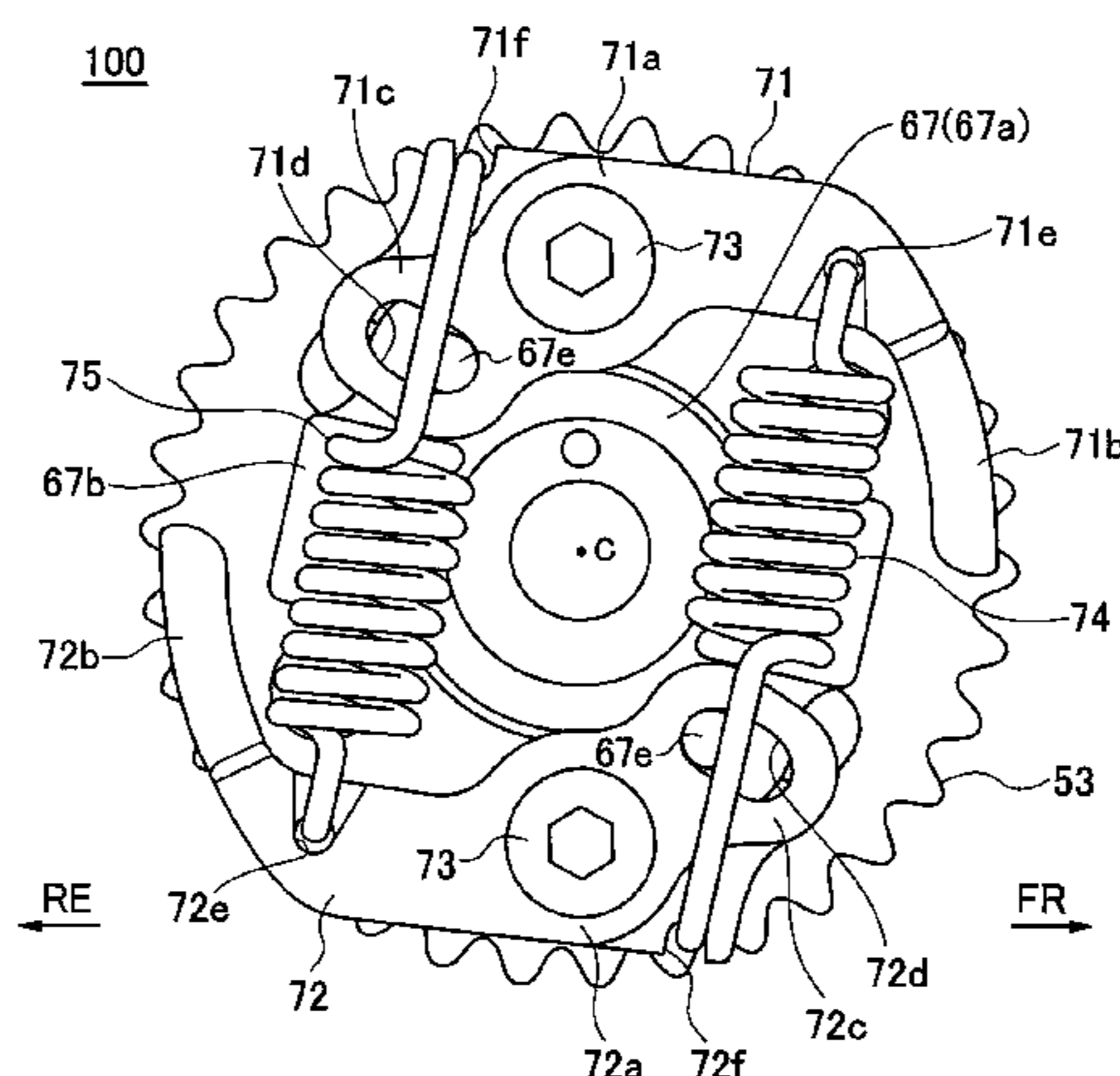
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(2013.01); **F01L 1/181** (2013.01); **F01L 1/267**
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13 Claims, 11 Drawing Sheets



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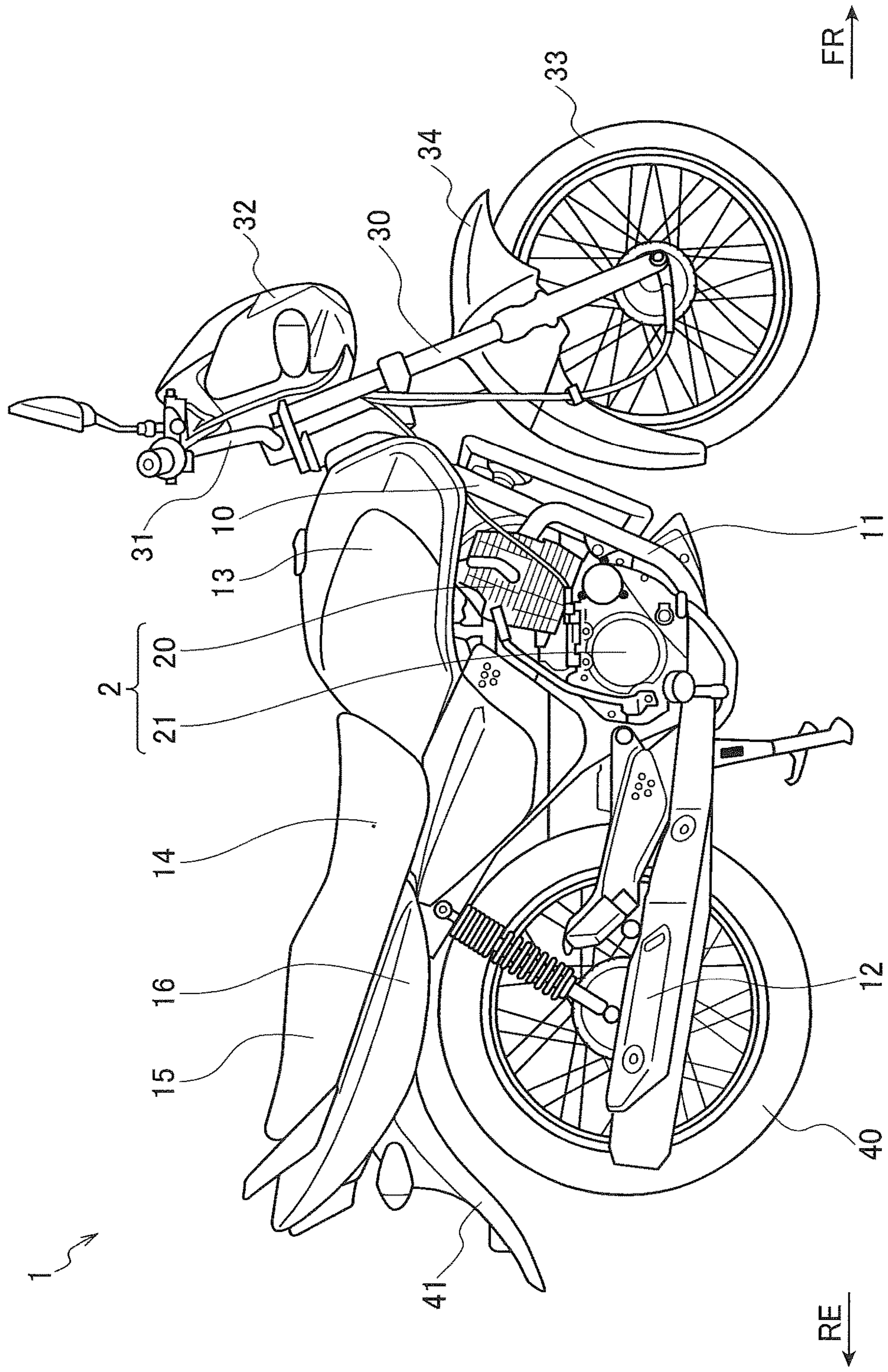
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FIG. 1



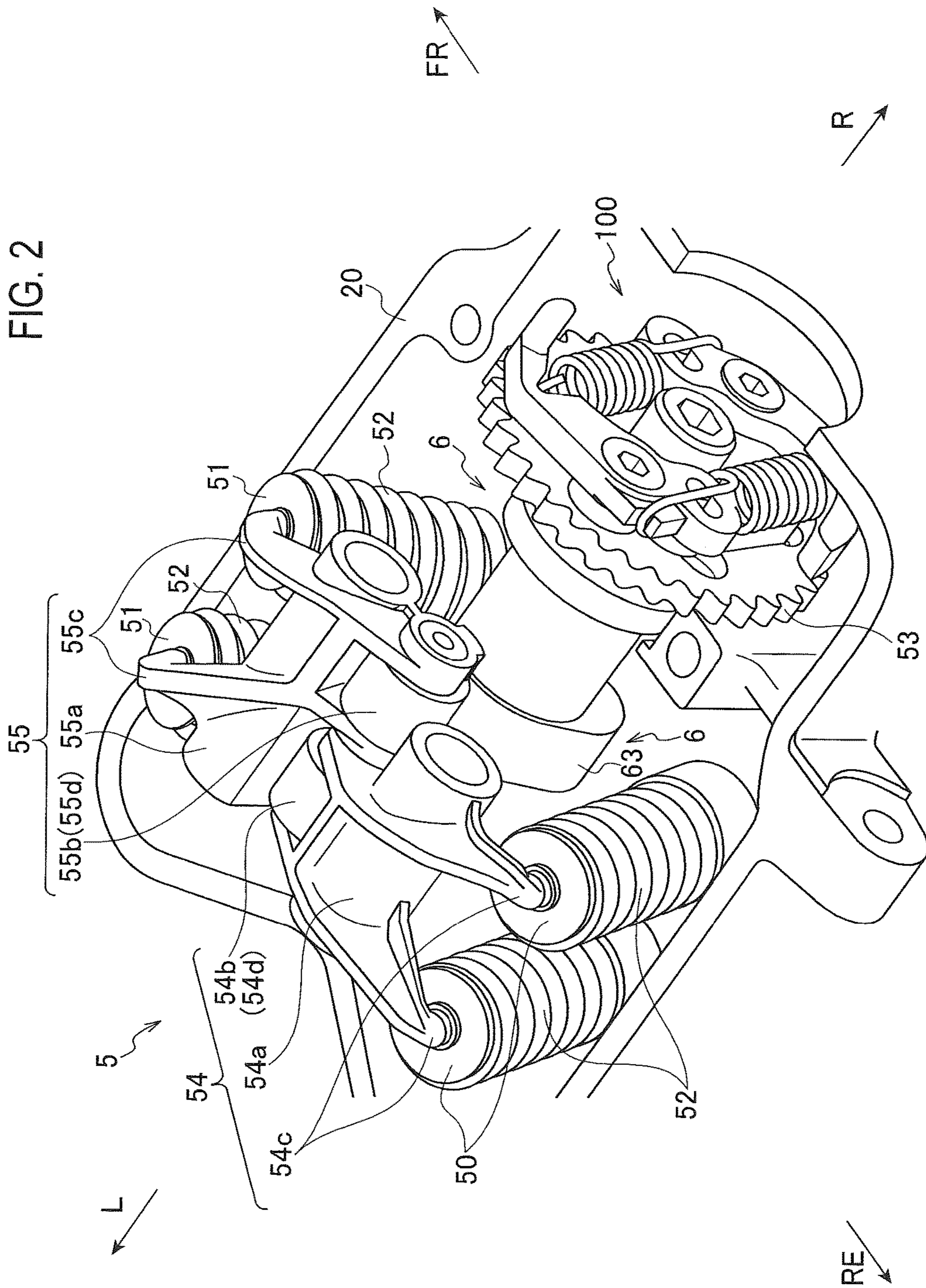


FIG. 3

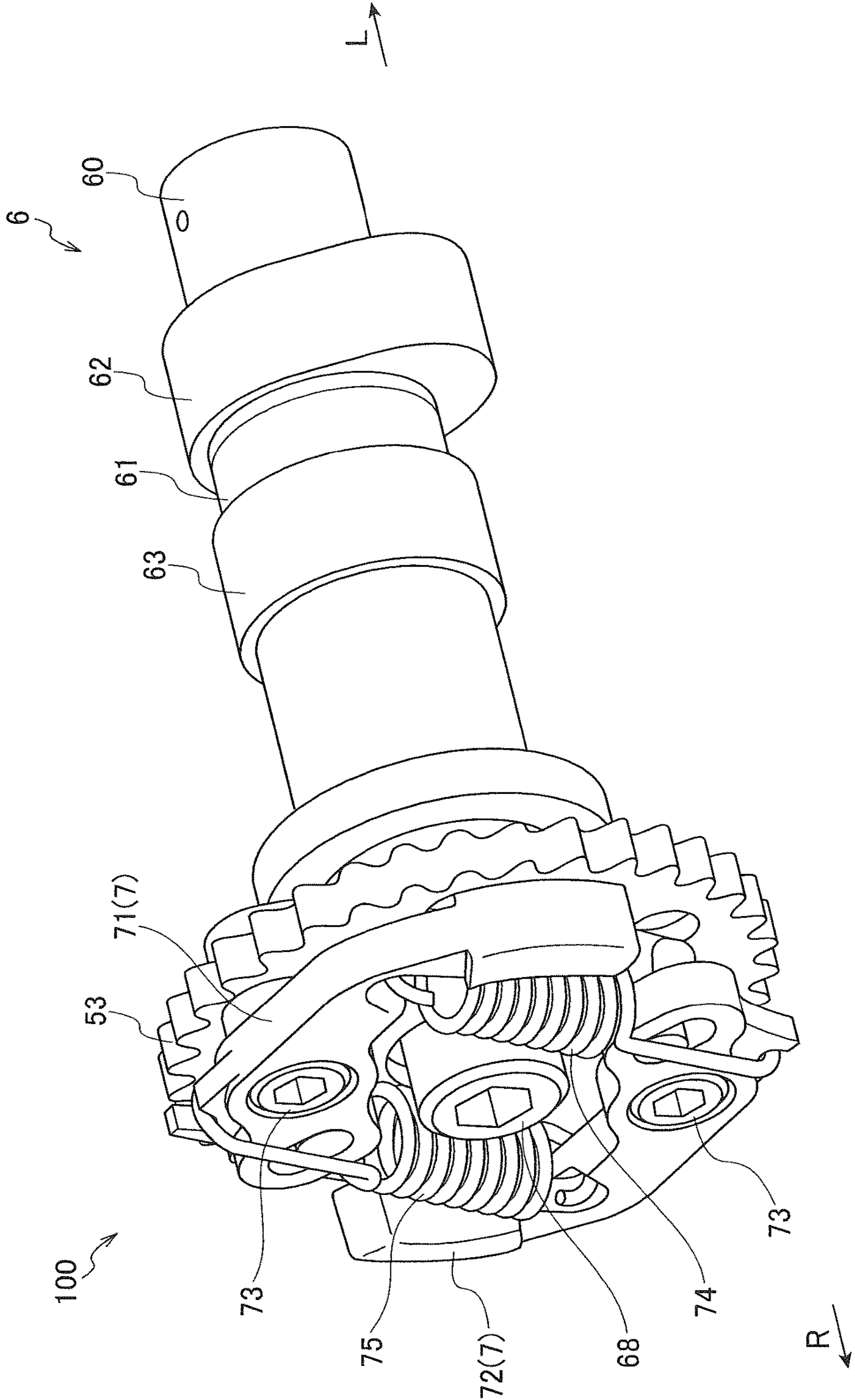


FIG. 4

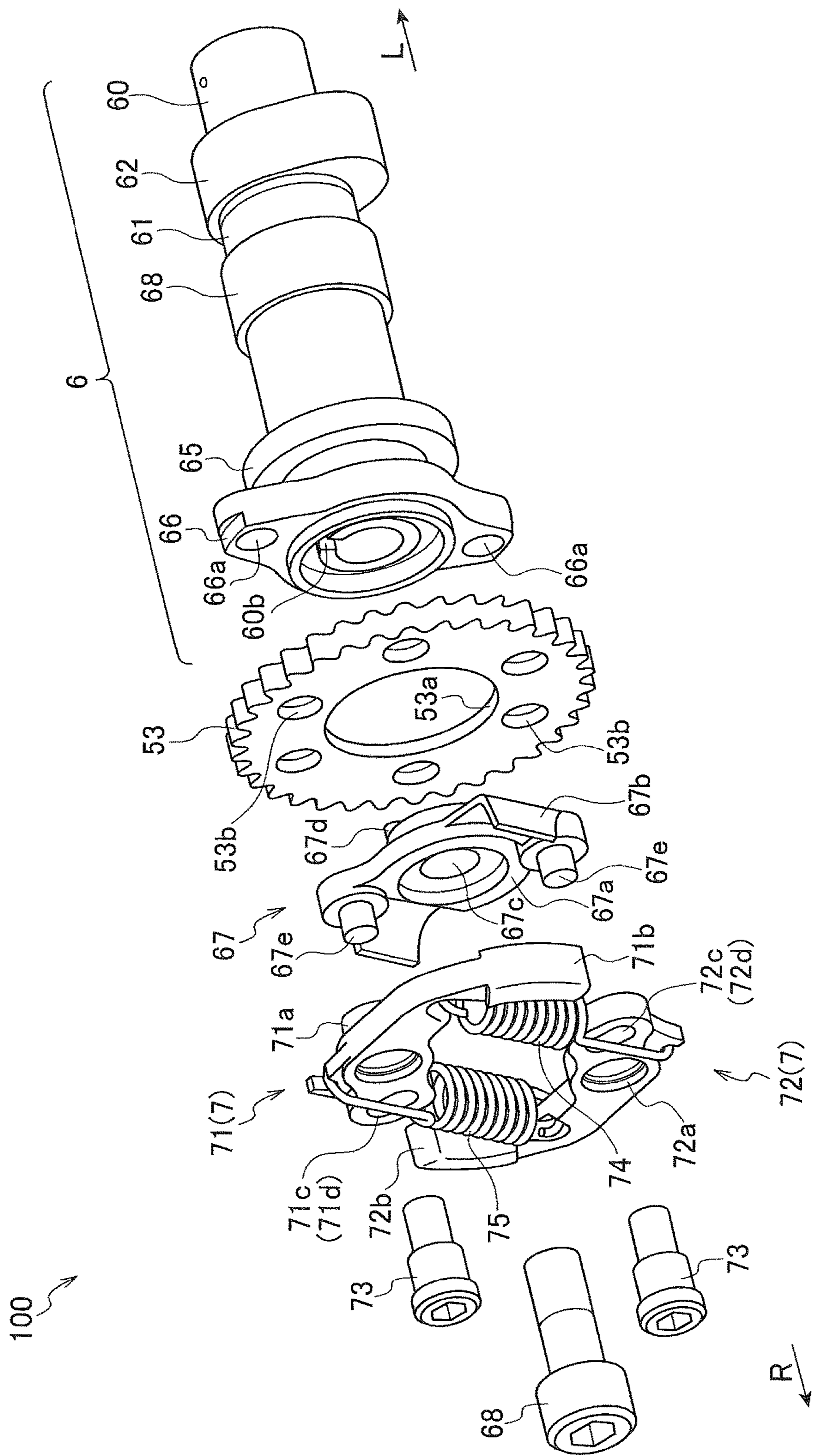


FIG. 5

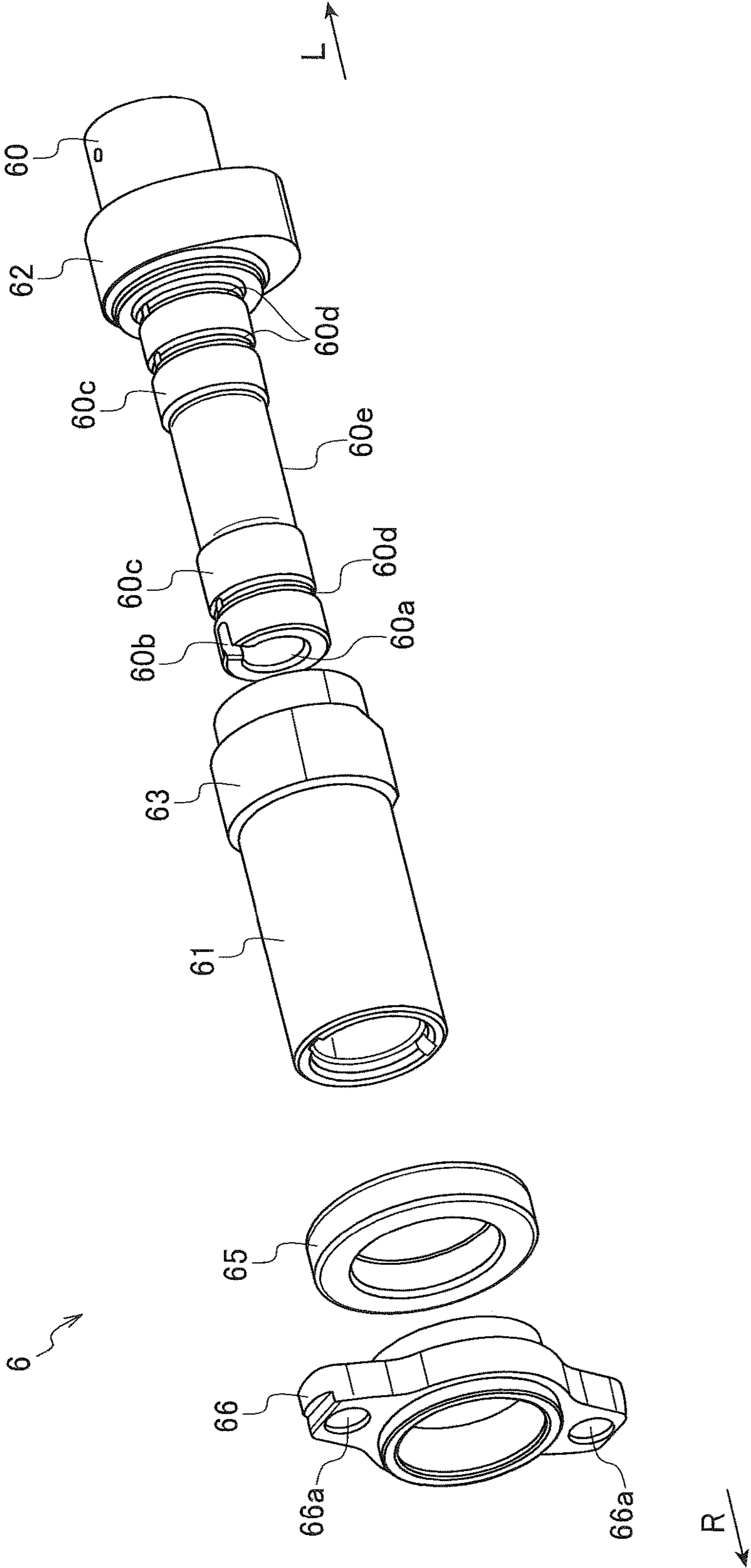


FIG. 6

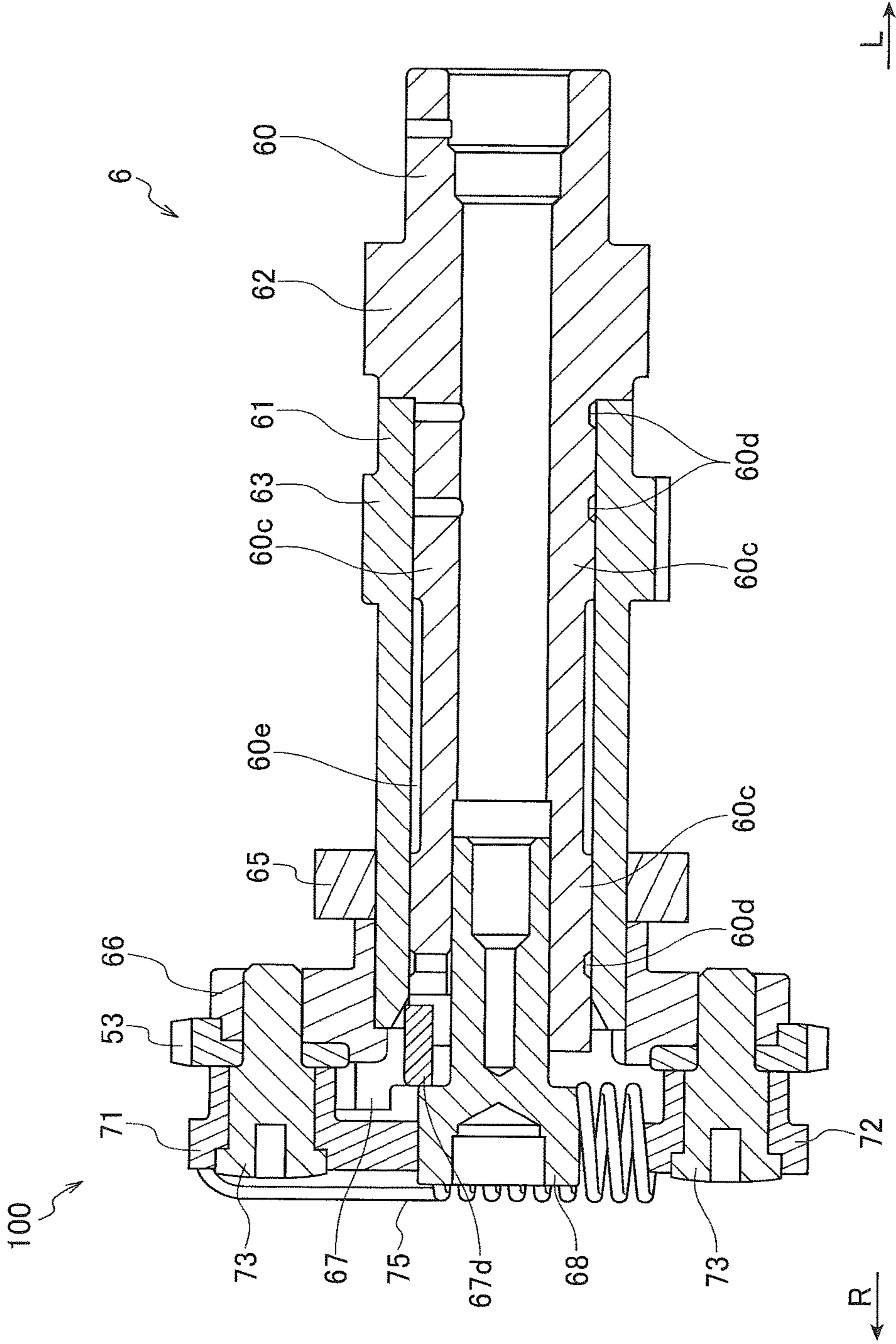


FIG. 7

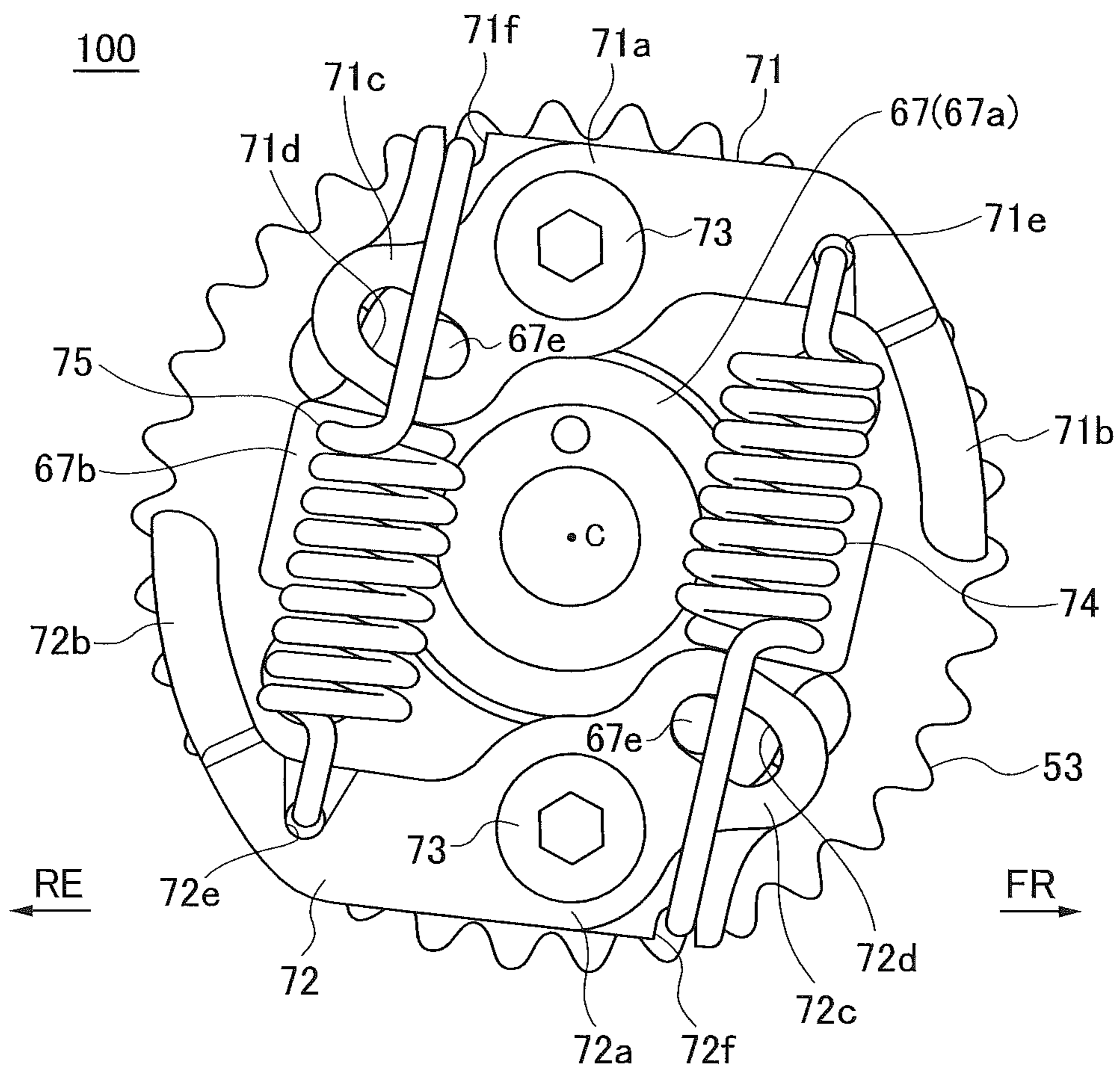


FIG. 8

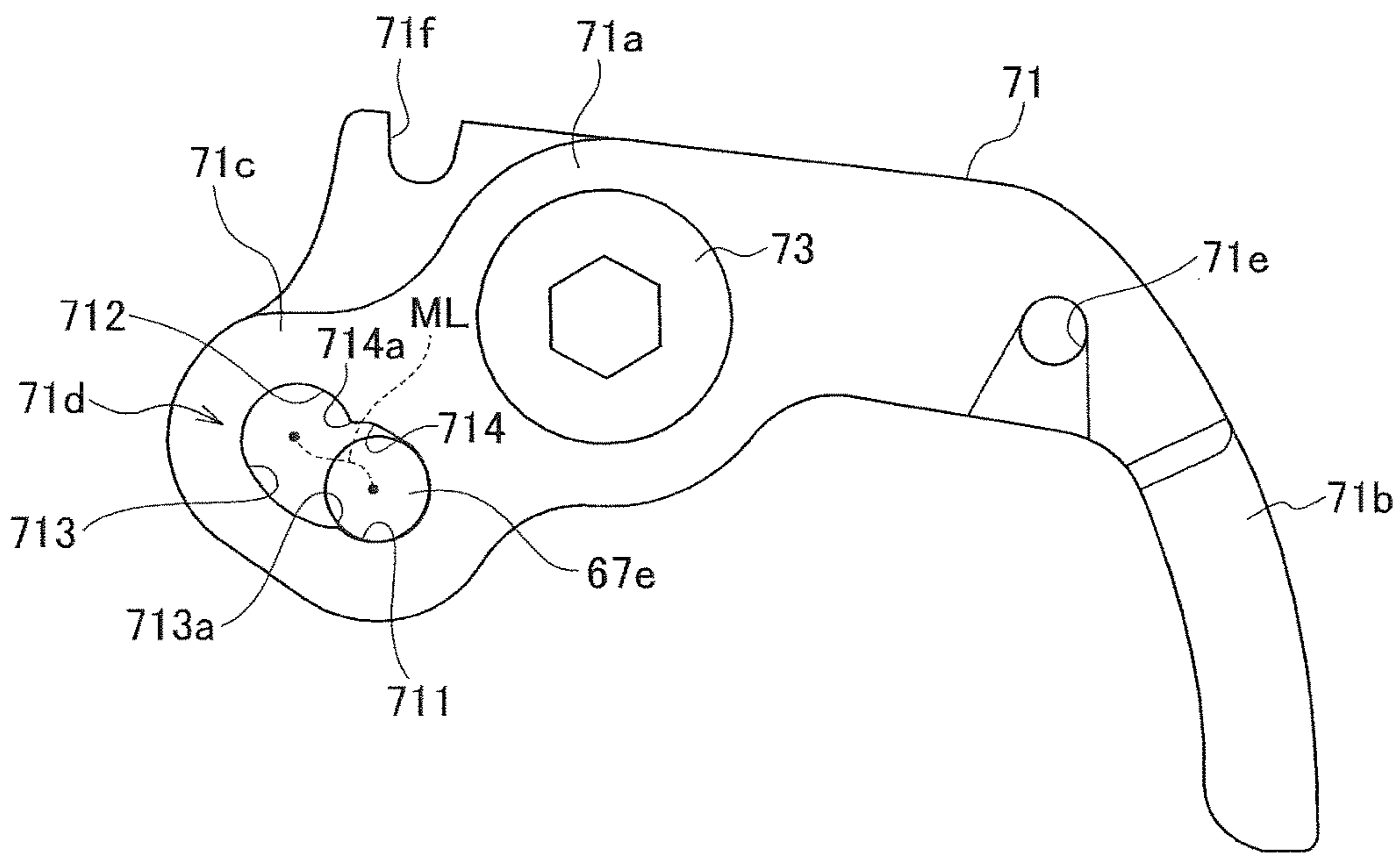


FIG. 9A

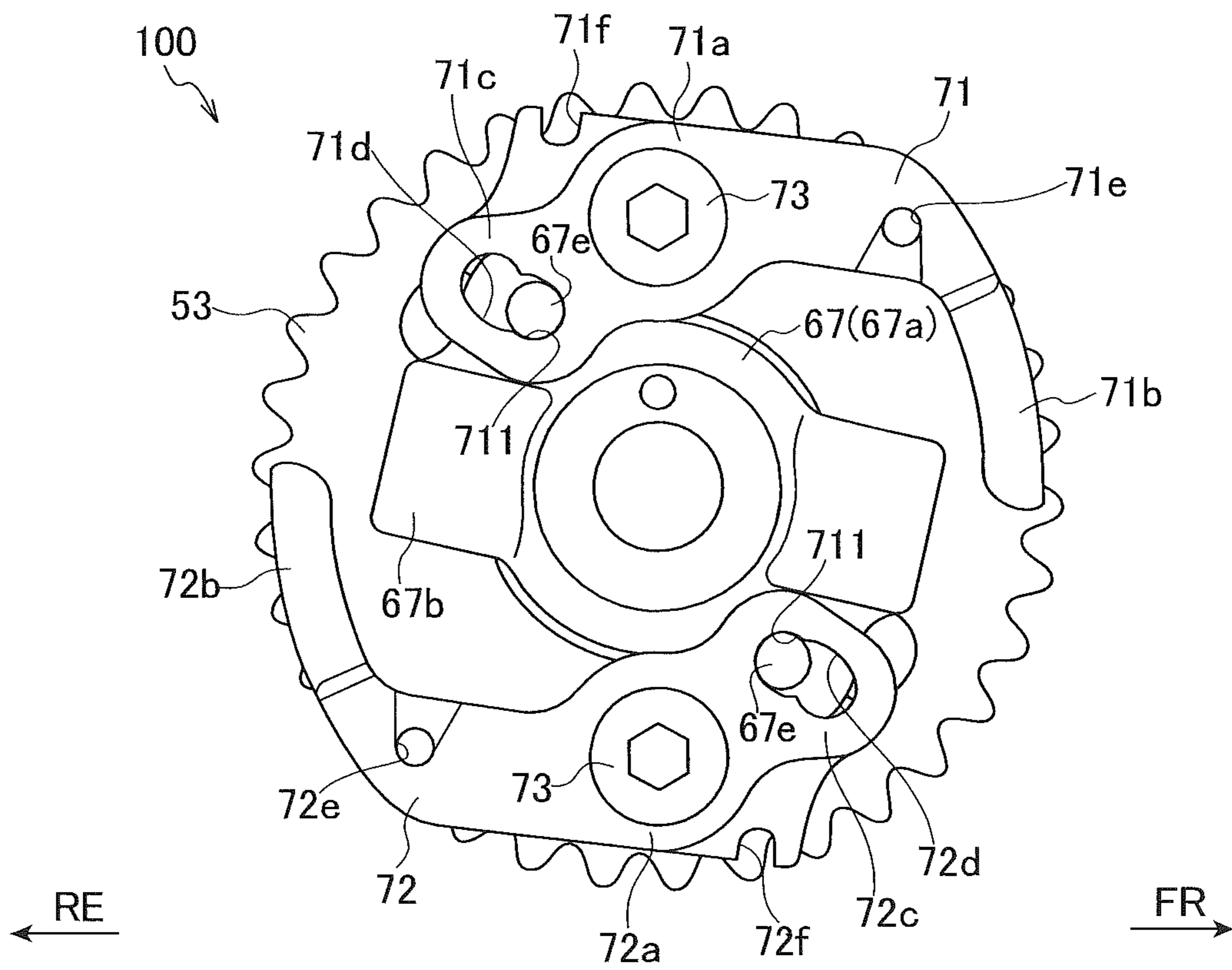


FIG. 9B

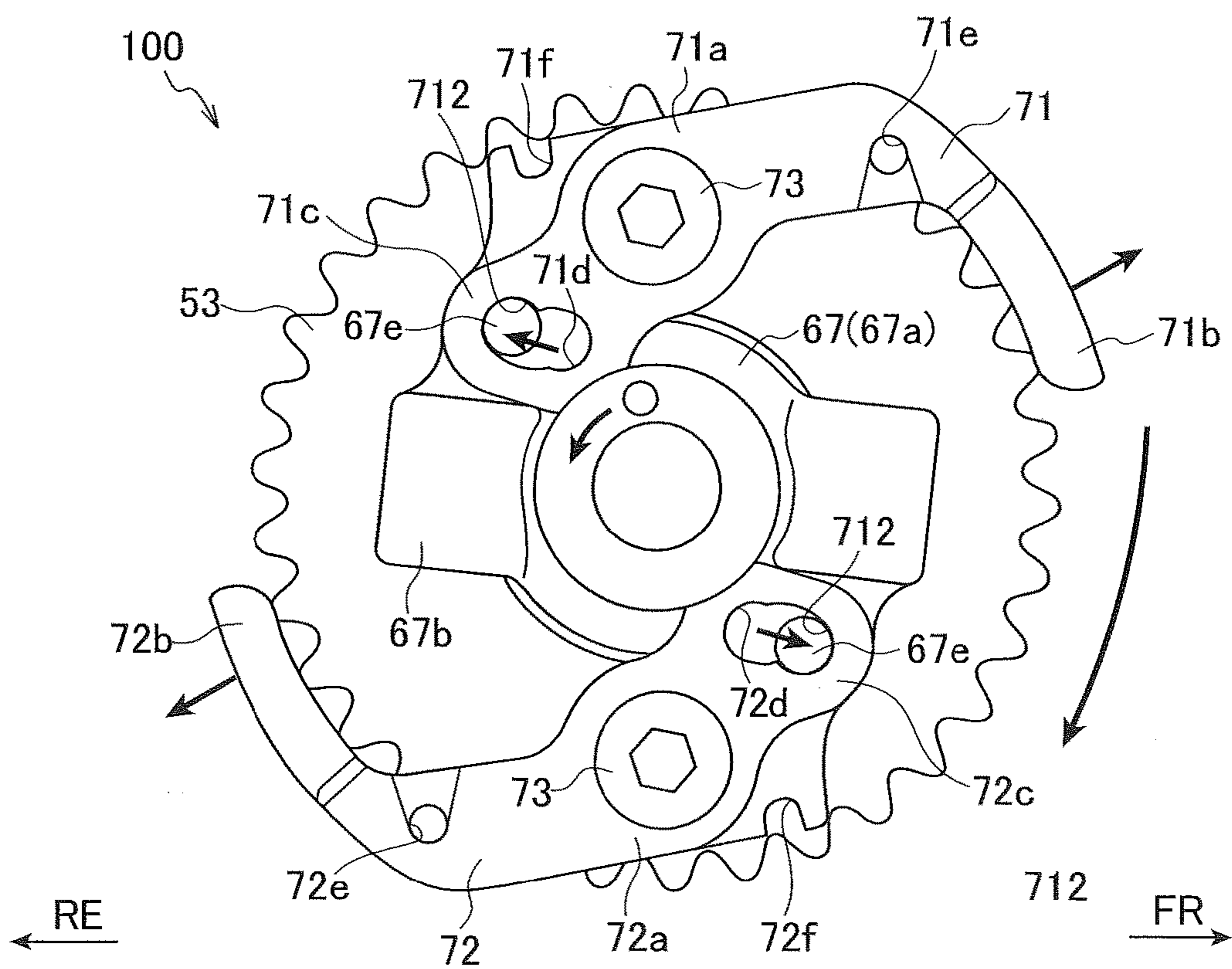
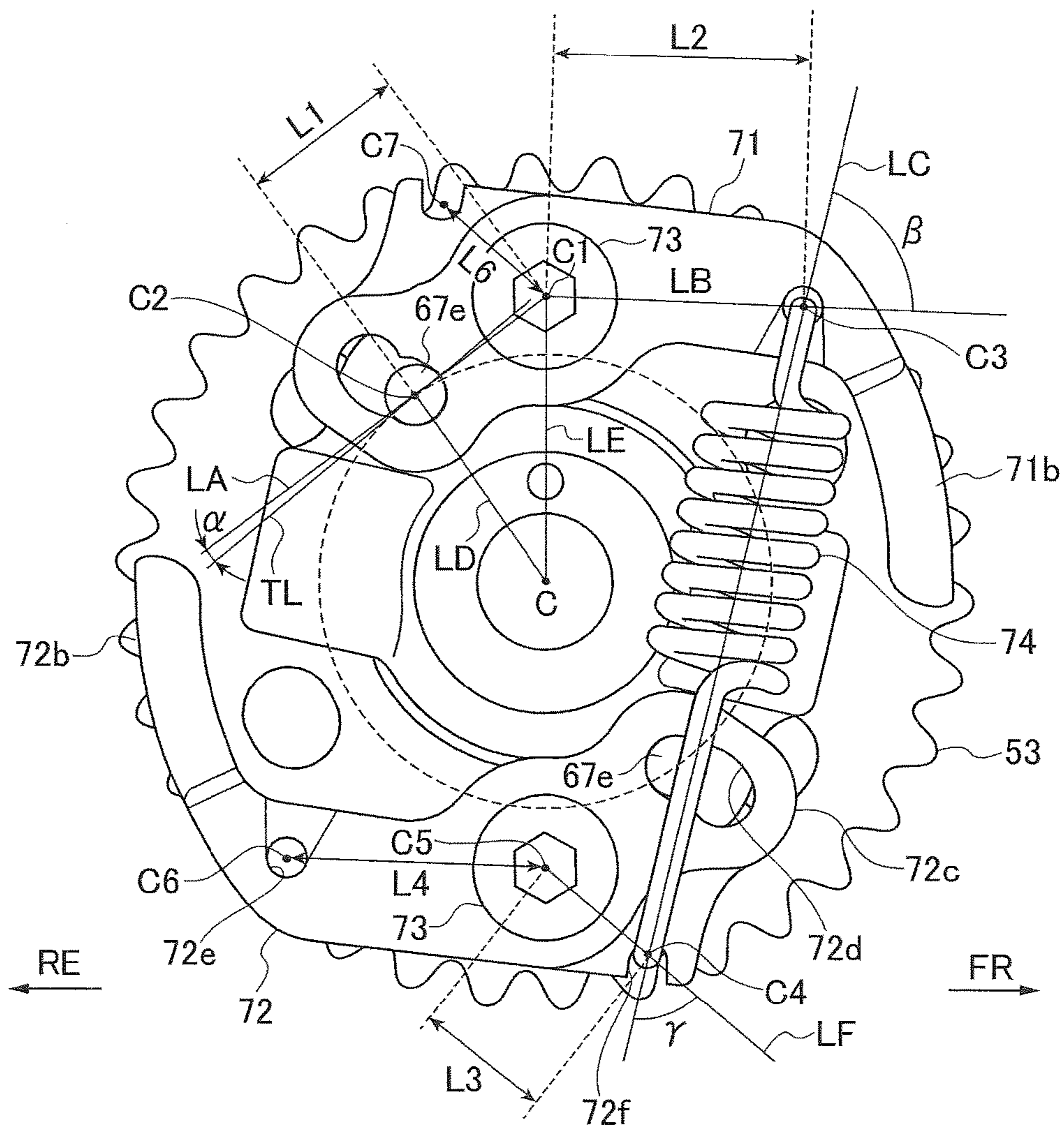


FIG. 10



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**VARIABLE VALVE MECHANISM, ENGINE,
AND AUTOMATIC TWO-WHEELED
VEHICLE**

INCORPORATION BY REFERENCE

This application is based upon and claims the benefit of priority from the corresponding Japanese Patent Application No. 2016-133288 filed on Jul. 5, 2016, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a variable valve mechanism, an engine, and an automatic two-wheeled vehicle, and particularly, to a variable valve mechanism which can be applied to a single overhead camshaft (SOHC) type valve train, an engine, and an automatic two-wheeled vehicle.

BACKGROUND ART

Hitherto, as an engine of an automatic two-wheeled vehicle, there is known an engine including a variable valve mechanism changing operation characteristics (including a valve opening/closing timing or a valve lift amount) of an intake valve and an exhaust valve in response to an engine rotation speed (for example, see JP 2011-1882 A). The variable valve mechanism described in JP 2011-1882 A includes a first driven member that is rotatable relatively to a cam shaft by a rotation transmitted from a crank shaft, a second driven member that is rotatable relatively to the first driven member and is relatively displaceable in the axial direction, and a centrifugal weight that is disposed between the first driven member and the second driven member. When the centrifugal weight moves by the action of a centrifugal force so that the second driven member is displaced relatively to the first driven member in the rotation direction, a phase of the cam shaft relatively to the crank shaft in the rotation direction is changed.

SUMMARY OF INVENTION

Technical Problem

However, in the variable valve mechanism described in JP 2011-1882 A, the second driven member is urged toward the first driven member by an urging member while the centrifugal weight is sandwiched between the first driven member and the second driven member. For this reason, since a resistance generated by the operation of the centrifugal weight is large, there is a need to perform a complex fine adjustment of the urging force in consideration of the influence of the resistance in order to smoothly change the phase of the cam shaft in the rotation direction.

The invention has been made in view of the above-described problems and an object of the invention is to provide a variable valve mechanism, an engine, and an automatic two-wheeled vehicle capable of more smoothly changing a phase of a cam shaft in a rotation direction.

Solution to Problem

An aspect of the present invention is summarized as a variable valve mechanism which changes an opening/closing timing of an intake valve or an exhaust valve in response to an engine rotation speed, the variable valve mechanism including: a cam sprocket which rotates in response to a

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rotation of a crank shaft; a cam shaft which is integrated with any one of intake side and exhaust side cams and is provided to be rotatable relatively to the cam sprocket; and a link member that engages with the cam sprocket and the cam shaft and transmits a rotation from the cam sprocket to the cam shaft, wherein the link member is supported by the cam sprocket to be swingable and swings in response to a change in rotation speed of the cam sprocket to rotate the cam shaft relatively to the cam sprocket.

According to this configuration, the link member swings in accordance with the rotation of the cam sprocket so that the cam shaft rotates relatively to the cam sprocket. For this reason, it is possible to change the phase of the cam shaft in the rotation direction by the swing operation of the link member. Accordingly, it is possible to suppress a resistance during an operation to be low compared to a conventional configuration in which the centrifugal weight is sandwiched between the pair of driven members. As a result, it is possible to more smoothly change the phase of the cam shaft in the rotation direction.

For example, in the above mentioned variable valve mechanism according to the present invention, the link member can include: a swing shaft which is fixed to the cam sprocket; a weight portion which is disposed to be separated from the swing shaft; and an engagement portion which engages with an engagement pin provided in the cam shaft and transmits a rotation of the cam sprocket to the cam shaft; the link member can be supported by the cam sprocket to be swingable; and the weight portion can move outward in the radial direction of the cam sprocket and the engagement portion moves to move the engagement pin in accordance with the rotation of the cam sprocket so that the cam shaft rotates relatively to the cam sprocket. According to this configuration, the weight portion moves outward in the radial direction of the cam sprocket and the engagement portion moves to move the engagement pin in accordance with the rotation of the cam sprocket so that the cam shaft rotates relatively.

Accordingly, it is possible to relatively rotate the cam shaft by swinging the link member using the centrifugal force generated in accordance with the rotation of the cam sprocket. For this reason, it is possible to stably change the phase of the cam shaft in the rotation direction with a simple and easy configuration without requiring a special control mechanism for relatively rotating the cam shaft. Further, since a friction force for the swing shaft is small and the weight portion can be moved even when a change in torque of the engine does not occur, it is possible to easily perform an inspection or an operation check of the cam shaft.

The above mentioned variable valve mechanism according to the present invention can further include: an urging member that is locked to the link member and urges the weight portion inward in the radial direction of the cam sprocket, wherein in a non-swing state of the link member, a distance L1 between a center of the swing shaft and a center of the engagement pin can be smaller than a distance L2 of an imaginary line connecting the center of the swing shaft to a locking position of the urging member on the link member. According to this configuration, since a distance between the swing shaft and the engagement pin is set to be small, it is possible to suppress a rotation moment for swinging the link member to be small when a driving reaction force given from the intake valve (the exhaust valve) to the cam is transmitted to the link member through the cam shaft and the engagement portion. Accordingly, it is possible to prevent a problem in which the link member easily swings.

In the above mentioned variable valve mechanism according to the present invention, in the non-swing state of the link member, an angle α formed by an imaginary line connecting the center of the swing shaft and the center of the engagement pin and a tangential line of a circle using a rotation axis of the cam shaft as a center and passing through the center of the engagement pin can be smaller than an angle β formed by an imaginary line connecting the center of the swing shaft and the locking position of the urging member and a center line of the urging member. According to this configuration, since the angle α is set to be smaller than the angle β , the rotation moment for swinging the link member when the driving reaction force given from the intake valve (the exhaust valve) to the cam is transmitted to the link member through the cam shaft and the engagement portion can be suppressed to be smaller than the rotation moment in which the urging member urges the link member. Accordingly, it is possible to prevent a problem in which the link member easily swings.

In the above mentioned variable valve mechanism according to the present invention, in the non-swing state of the link member, an imaginary line connecting the center of the swing shaft to the center of the engagement pin can intersect at a substantially right angle to an imaginary line connecting the center of the rotation axis of the cam shaft and the center of the engagement pin. According to this configuration, the swing shaft is disposed in the vicinity of the movement direction accompanied by the rotation of the cam shaft, that is, the tangential direction in the non-swing state. For this reason, even when the driving reaction force given from the intake valve (the exhaust valve) to the cam is transmitted to the link member through the cam shaft and the engagement portion, most elements of the driving reaction force can be set as an element for pulling the swing shaft. Accordingly, since the rotation moment for swinging the link member can be suppressed to maximum, it is possible to prevent a problem in which the link member easily swings.

For example, in the above mentioned variable valve mechanism according to the present invention, the engagement portion can be formed as a groove; and the groove can be provided with a first holding position which receives the engagement pin while the link member does not swing to a predetermined position or more and a second holding position which receives the engagement pin while the link member swings to a predetermined position or more and a first stopper portion which protrudes toward a facing inner wall surface of the groove in the vicinity of the first holding position is provided in an inner wall surface disposed at a farther side from the swing shaft in the inner wall surface of the groove. According to this configuration, since the first stopper portion which protrudes toward the facing inner wall surface of the groove in the vicinity of the first holding position is provided in the inner wall surface disposed at a farther side from the swing shaft in the inner wall surface of the groove, the engagement pin received in the first holding position cannot move easily. Accordingly, it is possible to suppress the vibration of the link member even when the driving reaction force given from the intake valve (the exhaust valve) to the cam is transmitted to the link member through the cam shaft and the engagement portion.

In the above mentioned variable valve mechanism according to the present invention, a second stopper portion which protrudes toward a facing inner wall surface of the groove in the vicinity of the second holding position can be provided in the inner wall surface disposed at a close side to the swing shaft in the inner wall surface of the groove. According to this configuration, since the second stopper portion which

protrudes toward the facing inner wall surface of the groove in the vicinity of the second holding position is provided in the inner wall surface disposed at a close side to the swing shaft in the inner wall surface of the groove, the engagement pin received in the second holding position cannot move easily. Accordingly, it is possible to suppress the vibration of the link member even when the driving reaction force given from the intake valve (the exhaust valve) to the cam is transmitted to the link member through the cam shaft and the engagement portion.

Especially, in the above mentioned variable valve mechanism according to the present invention, the groove can be provided with a substantially S-shaped moving line in which the center of the engagement pin in a front view bypasses the first stopper portion and the second stopper portion. According to this configuration, since the groove is provided with the substantially S-shaped moving line in which the center of the engagement pin bypasses the first stopper portion and the second stopper portion, it is possible to prevent a problem in which the engagement pin received in the first holding position or the second holding position moves easily. Accordingly, it is possible to swing the link member and to return the link member to the non-swing state at a desired timing.

In the above mentioned variable valve mechanism according to the present invention, the urging member can be disposed so that one end thereof is locked to a position near the weight portion in relation to the swing shaft and an angle β interposing the rotation axis of the cam sprocket among angles formed by an imaginary line passing through the locking position of the urging member and the center of the swing shaft and the center line of the urging member becomes an acute angle. According to this configuration, since the angle β which decreases in accordance with an increase in swing angle of the link member is set to an acute angle in advance, it is possible to increase the rotation radius of the weight portion in accordance with an increase in swing angle of the link member and to increase the centrifugal force applied to the weight portion in proportional to the rotation radius. Since the urging force increases as the swing angle of the link member increases in accordance with an increase in rotation speed of the cam sprocket, the link member can be immediately operated. Meanwhile, the link member can be returned to the non-swing state in accordance with a decrease in rotation speed of the cam sprocket. As a result, it is possible to improve the responsiveness of the operation of the link member in response to the rotation speed of the cam sprocket.

For example, in the above mentioned variable valve mechanism according to the present invention, the link member can include a first link member disposed at one side with the rotation axis of the cam sprocket interposed therebetween and a second link member disposed at the other side; and the urging member can include a first urging member disposed at one side with the rotation axis of the cam sprocket interposed therebetween and a second urging member disposed at the other side. According to this configuration, since the first link member and the second link member are disposed at the opposite side with the rotation axis of the cam sprocket interposed therebetween and the first urging member and the second urging member are disposed at the opposite side with the rotation axis of the cam sprocket interposed therebetween, it is possible to dispose the link member and the urging member with a good balance. For this reason, it is possible to keep the smooth rotation of the cam shaft without requiring a weight portion for ensuring a balance.

Especially, in the above mentioned variable valve mechanism according to the present invention, the first link member and the second link member can be disposed to be point-symmetrical to each other with respect to the center of the rotation axis of the cam sprocket and the first urging member and the second urging member are disposed to be point-symmetrical to each other with respect to the center of the rotation axis of the cam sprocket. According to this configuration, since the first link member and the second link member are disposed to be point-symmetrical to each other with respect to the center of the rotation axis of the cam sprocket, it is possible to transmit a rotation force from the cam sprocket through a plurality of link members to be symmetrical each other with respect to the cam shaft. Accordingly, it is possible to smoothly rotate the cam shaft. Further, since the first link member and the second link member are disposed to be point-symmetrical to each other with respect to the center of the rotation axis of the cam sprocket, it is possible to keep the smooth rotation of the cam shaft without requiring a weight portion for ensuring a balance.

In the above mentioned variable valve mechanism according to the present invention, in the first link member and the second link member, the weight portion can be disposed at one side and the engagement portion is disposed at the other side with respect to an imaginary line connecting the center of the swing shaft and the center of the rotation axis of the cam sprocket; one end of the first urging member can be locked to a position near the weight portion in relation to the swing shaft of the first link member and the other end thereof is locked to a position near the engagement portion in relation to the swing shaft of the second link member; and one end of the second urging member can be locked to a position near the weight portion in relation to the swing shaft of the second link member and the other end thereof is locked to a position near the engagement portion in relation to the swing shaft of the first link member. According to this configuration, both the first urging member and the second urging member are locked in the first link member and the second link member. For this reason, when one ends (ends on the side of the weight portion) of the first urging member and the second urging member are pulled outward in the radial direction of the cam sprocket, the other ends (ends on the side of the engagement portion) of the second urging member and the first urging member move inward in the radial direction of the cam sprocket. Accordingly, since the expansion/contraction amounts of the first urging member and the second urging member can be decreased, a burden on the urging member can be reduced. Further, since both ends of the first urging member and the second urging member are locked to the first link member and the second link member, no interference occurs since the urging member is also operated when the link member swings. For this reason, since the first link member and the second link member can be disposed at a close position, the variable valve mechanism can have a simple and compact structure.

In the above mentioned variable valve mechanism according to the present invention, a distance between a locking position of the first urging member at the side of the weight portion in the first link member and the center of the swing shaft of the first link member can be larger than a distance between a locking position of the first urging member at the side of the engagement portion in the second link member and the center of the swing shaft of the second link member; and a distance between a locking position of the second urging member at the side of the weight portion in the second link member and the center of the swing shaft of the

second link member can be larger than a distance between a locking position of the second urging member at the side of the engagement portion in the first link member and the center of the swing shaft of the first link member. According to this configuration, even in a structure which pulls both the weight portion and the engagement portion of the plurality of link members, the rotation moment at the weight portion is larger than the rotation moment at the engagement portion and thus both link members can be urged in a non-swing direction. Accordingly, it is possible to stably change the phase of the cam shaft in the rotation direction even when the locking position of the urging member is provided at both the weight portion and the engagement portion in the narrow space.

Further, it is preferable that the engine according to the invention include the variable valve mechanism. According to this configuration, an effect obtained by the variable valve mechanism can be also obtained by the engine.

Further, it is preferable that an automatic two-wheeled vehicle according to the invention include an engine. According to this configuration, an effect obtained by the engine can be also obtained by the automatic two-wheeled vehicle.

According to the invention, it is possible to more smoothly change the phase of the rotation direction of the cam shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view illustrating a schematic configuration of an automatic two-wheeled vehicle including an engine that adopts a variable valve mechanism according to an embodiment;

FIG. 2 is a perspective view of a valve train according to the embodiment;

FIG. 3 is a perspective view illustrating a part of the variable valve mechanism that is assembled to the valve train according to the embodiment;

FIG. 4 is an exploded perspective view of the variable valve mechanism illustrated in FIG. 3;

FIG. 5 is an exploded perspective view of a cam shaft assembly according to the embodiment;

FIG. 6 is a cross-sectional view of the variable valve mechanism illustrated in FIG. 3;

FIG. 7 is a side view of the variable valve mechanism illustrated in FIG. 3;

FIG. 8 is an enlarged view of a link member that belongs to the variable valve mechanism according to the embodiment;

FIGS. 9A and 9B are diagrams illustrating a positional relation of components of a link member of the variable valve mechanism according to the embodiment; and

FIG. 10 is a diagram illustrating an operation of the variable valve mechanism according to the embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of the invention will be described in detail with reference to the accompanying drawings. Further, in the following description, an example in which a variable valve mechanism according to the invention is applied to an engine of an automatic two-wheeled vehicle will be described, but the application target can be changed without limitation. For example, the variable valve mechanism according to the invention may be also applied to engines of other automatic two-wheeled vehicles,

buggy type automatic three-wheeled vehicles, or automatic four-wheeled vehicles. Regarding the direction, the front side of the vehicle will be denoted by an arrow FR, the rear side of the vehicle will be denoted by an arrow RE, the left side of the vehicle will be denoted by L, and the right side of the vehicle will be denoted by an arrow R. Further, in the drawings below, a part of the configuration will be omitted for convenience of the description.

Referring to FIG. 1, a schematic configuration of an automatic two-wheeled vehicle that employs an engine according to the embodiment will be described. FIG. 1 is a side view illustrating a schematic configuration of an automatic two-wheeled vehicle including an engine that employs the variable valve mechanism according to the embodiment.

As illustrated in FIG. 1, an automatic two-wheeled vehicle 1 has a configuration in which an engine 2 is suspended on a vehicle body frame 10 formed of aluminum alloy or a steel product equipped with a power unit, an electricity system, and the like. The engine 2 is, for example, a single cylinder four-cycle engine. The engine 2 has a configuration in which a cylinder assembly 20 (hereinafter, simply referred to as a cylinder 20) obtained by the combination of a cylinder block or a cylinder head is attached to an upper portion of a crank casing 21.

Components such as a piston (not illustrated) or a valve train 5 (see FIG. 2) are received inside the cylinder 20. Although it will be described later in detail, the valve train 5 according to the embodiment is configured as a single overhead camshaft (SOHC) type valve train. Further, various shafts that transmit a rotation of a crank shaft (not illustrated) are received inside the crank casing 21 in addition to the crank shaft.

An exhaust pipe 11 is connected to a front exhaust port of the engine 2. The exhaust pipe 11 extends downward from the exhaust port, is bent under the crank casing 21, and extends toward the rear side of the vehicle body. A muffler 12 is attached to a rear end of the exhaust pipe 11. An exhaust gas which is produced after combustion is discharged to the outside through the exhaust pipe 11 and the muffler 12.

A fuel tank 13 is disposed at an upper portion of the vehicle body frame 10. A driver seat 14 and a passenger seat 15 are disposed at the rear side of the fuel tank 13 along with a rear cowl 16. A pair of left and right front forks 30 are supported by a front head portion of the vehicle body frame 10 to be steerable along with a handlebar 31. A head lamp 32 is provided at the front side of the handlebar 31. A front wheel 33 is supported by a lower portion of the front fork 30 to be steerable and an upper portion of the front wheel 33 is covered by a front fender 34.

A swing arm (not illustrated) is connected to a rear portion of the vehicle body frame 10 to be swingable up and down. A rear wheel 40 is supported by the rear portion of the swing arm to be rotatable. A driven sprocket (not illustrated) is provided at the left side of the rear wheel 40 and power of the engine 2 is transmitted to the rear wheel 40 by a drive chain (not illustrated). An upper portion of the rear wheel 40 is covered by a rear fender 41 provided at a rear portion of the rear cowl 16.

Next, the valve train according to the embodiment will be described with reference to FIGS. 2 and 3. FIG. 2 is a diagram illustrating a state where a cylinder head cover is separated from the engine and is a perspective view of the valve train according to the embodiment. FIG. 3 is a perspective view illustrating a part of a variable valve mechanism that is assembled to the valve train according to the embodiment.

As illustrated in FIG. 2, the valve train 5 which controls the opening/closing of an intake valve 50 and an exhaust valve 51 is provided at an upper portion of the cylinder 20. As described above, the valve train 5 is an SOHC type valve train and has a configuration in which a cam shaft assembly 6 (hereinafter, simply referred to as a cam shaft 6) is disposed above the intake valve 50 and the exhaust valve 51.

Two intake valves 50 are disposed at the cam shaft 6 on the rear side of the vehicle to be arranged in the left and right direction (the vehicle width direction). Further, two exhaust valves 51 are disposed at the cam shaft 6 on the front side of the vehicle to be arranged in the left and right direction. Each of the intake valves 50 and the exhaust valves 51 is provided with a valve spring 52. The intake valves 50 and the exhaust valves 51 are constantly urged upward (in a closing direction) by the valve springs 52.

The cam shaft 6 extends in the left and right direction (see FIG. 3). An intake cam 62 and an exhaust cam 63 are provided at the cam shaft 6 to be arranged in the left and right direction (the intake cam 62 is not illustrated in FIG. 2, but is illustrated in FIG. 3). Specifically, as illustrated in FIGS. 2 and 3, the left side in the axial direction is the intake cam 62 and the right side in the axial direction is the exhaust cam 63. Further, a right end of the cam shaft 6 is provided with a cam sprocket 53. A cam chain (not illustrated) which transmits the rotation of the crank shaft is wound around the cam sprocket 53.

For example, the cam shaft 6 is obtained by coaxially assembling an intake cam shaft 60 constituting a first cam shaft and an exhaust cam shaft 61 constituting a second cam shaft (see FIGS. 4 and 5). Although a detailed description will be made below, the cam shaft 6 and the peripheral components thereof constitute a variable valve mechanism 100 which changes the opening/closing timings of the intake valve 50 and the exhaust valve 51.

As illustrated in FIG. 2, an intake rocker arm 54 which opens and closes the intake valve 50 and an exhaust rocker arm 55 which opens and closes the exhaust valve 51 are provided above the cam shaft 6 (the intake cam 62 and the exhaust cam 63). The intake rocker arm 54 is supported to be swingable by an intake rocker shaft (not illustrated) extending in the left and right direction. Specifically, the intake rocker arm 54 includes a support portion 54a which serves as a swing support point, a contact portion 54b which contacts the intake cam 62, and a pressing portion 54c which presses the intake valve 50.

The support portion 54a has a cylindrical shape through which the intake rocker shaft is insertable. The contact portion 54b extends forward and downward from the support portion 54a and a roller 54d is attached to a front end thereof. An outer surface of the roller 54d is in contact with an outer surface of the intake cam 62. The pressing portion 54c is bifurcated backward and downward from the support portion 54a and front ends thereof are in contact with an upper end of the intake valve 50.

The exhaust rocker arm 55 is also supported to be swingable by an exhaust rocker shaft (not illustrated) extending in the left and right direction. Specifically, the exhaust rocker arm 55 includes a support portion 55a which serves as a swing support point, a contact portion 55b which contacts the exhaust cam 63, and a pressing portion 55c which presses the exhaust valve 51.

The support portion 55a has a cylindrical shape through which the exhaust rocker shaft is insertable. The contact portion 55b extends backward and downward from the support portion 55a and a roller 55d is attached to a front end thereof. An outer surface of the roller 55d is in contact with

an outer surface of the exhaust cam **63**. The pressing portion **55c** is bifurcated forward and downward from the support portion **55a** and front ends thereof are in contact with an upper end of the exhaust valve **51**.

In the valve train **5** with such a configuration, when the cam shaft **6** rotates along with the rotation of the crank shaft, the contact portion **54b** (the contact portion **54b**) slides along a cam surface (the outer surface) of the intake cam **62** (the exhaust cam **63**). Especially, the contact portion **54b** (the contact portion **55b**) is pressed upward by a protruding portion of the intake cam **62** (the exhaust cam **63**). For this reason, the intake rocker arm **54** (the exhaust rocker arm **55**) rotates about the support portion **54a** (the support portion **55a**) as a support point and the pressing portion **54c** (the pressing portion **55c**) moves downward.

At this time, the pressing portion **54c** (the pressing portion **55c**) presses the intake valve **50** (the exhaust valve **51**) downward (in an opening direction) against an urging force of the valve spring **52**. As a result, the intake valve **50** (the exhaust valve **51**) is opened. When the contact portion **54b** (the contact portion **55b**) gets over the protruding portion of the intake cam **62** (the exhaust cam **63**), the intake valve **50** (the exhaust valve **51**) is urged upward by the urging force of the valve spring **52**. As a result, the intake valve **50** (the exhaust valve **51**) is closed. In this way, the opening and closing of the intake valve **50** and the exhaust valve **51** is controlled.

Next, the variable valve mechanism **100** that is assembled to the valve train **5** according to the embodiment will be described with reference to FIGS. **3** and **4**. FIG. **4** is an exploded perspective view of the variable valve mechanism **100** illustrated in FIG. **3**. Additionally, FIGS. **3** and **4** illustrate a state (a non-swing state) where a pair of link members **7** (a first link member **71** and a second link member **72**) constituting the variable valve mechanism **100** do not swing.

As described above, the valve train **5** according to the embodiment (see FIG. **2**) includes the variable valve mechanism **100** which changes the opening and closing timing of the intake valve **50** or the exhaust valve **51** (see FIG. **2**) in response to an engine rotation speed. As illustrated in FIG. **3**, the variable valve mechanism **100** is a so-called governor type variable valve timing mechanism which advances the valve timing of the intake valve **50** by using a centrifugal force generated by the rotation of the cam shaft **6** (the cam sprocket **53**).

As illustrated in FIGS. **3** and **4**, the variable valve mechanism **100** includes the cam shaft **6**, the cam sprocket **53**, and the pair of link members **7** (the first link member **71** and the second link member **72**). The cam sprocket **53** is provided at a right end of the cam shaft **6** and the pair of link members **7** are attached to a right surface of the cam sprocket **53**. Hereinafter, components of the variable valve mechanism **100** will be described.

First, a configuration of the cam shaft **6** including the variable valve mechanism **100** according to the embodiment will be described. FIG. **5** is an exploded perspective view of the cam shaft **6** according to the embodiment. FIG. **6** is a cross-sectional view of the variable valve mechanism **100** illustrated in FIG. **3**. In FIG. **5**, a link flange **67** constituting a part of the cam shaft **6** is omitted for convenience of the description.

As illustrated in FIGS. **5** and **6**, the cam shaft **6** has a configuration in which a sprocket flange **66** is attached to a right end of the exhaust cam shaft **61** through a bearing **65**, the cylindrical exhaust cam shaft **61** is attached to the intake cam shaft **60**, and an link flange **67** is attached to a right end

of the intake cam shaft **60** (the link flange **67** is not illustrated in FIG. **5**, but is illustrated in FIG. **4**).

The intake cam shaft **60** is formed in a hollow shape and extends in the left and right direction. The intake cam **62** is integrally formed at the left end of the intake cam shaft **60**. A screw hole **60a** for a bolt **68** (see FIGS. **4** and **6**) to be described later is provided at the right end of the intake cam shaft **60**. Further, an engagement groove **60b** which engages with an engagement pin **67d** of the link flange **67** is formed at the outer peripheral side of the right end of the intake cam shaft **60**.

Further, a portion which is located on the right side of the intake cam **62** in the intake cam shaft **60** and is received inside the exhaust cam shaft **61** is formed so that a base end and a right end are larger (thicker) than an intermediate portion **60e** in the radial direction. The thick portion of the intake cam shaft **60** serves as a support portion **60c** which supports the exhaust cam shaft **61**. Specifically, an outer diameter of the support portion **60c** is substantially equal to an inner diameter of the exhaust cam shaft **61**. Further, an outer surface of the support portion **60c** is provided with an annular groove **60d**. The annular groove **60d** and the intermediate portion **60e** serve as an oil supply path which supplies oil to a sliding surface between the intake cam shaft **60** and the exhaust cam shaft **61**.

The exhaust cam shaft **61** is formed such that the exhaust cam **63** is integrally formed at a left end, that is, an end opposite to the sprocket flange **66** and has a cylindrical shape through which the intake cam shaft **60** is insertable. Specifically, an inner diameter of the exhaust cam shaft **61** is set to be slightly larger than an outer diameter of the intake cam shaft **60**. A length of the exhaust cam shaft **61** is substantially the same as a length of the intake cam shaft **60** on the right side of the intake cam **62**. Further, the exhaust cam shaft **61** and the intake cam shaft **60** are formed to be rotatable relatively to each other.

The sprocket flange **66** which is provided at the right end of the exhaust cam shaft **61** is provided with two screw holes **66a** corresponding to the penetration hole **53b** of the cam sprocket **53**. The sprocket flange **66** is attached to the exhaust cam shaft **61** to be rotatable together. Further, the cam sprocket **53** is fixed to the sprocket flange **66** by a bolt **73** to be described later.

The link flange **67** includes, as illustrated in FIG. **4**, a circular portion **67a** which engages with the intake cam shaft **60** and a flange portion **67b** which is widened outward in the radial direction from the outer periphery of the circular portion **67a**. A circular hole **67c** is formed at the center of the circular portion **67a**. When the bolt **68** is inserted through the circular hole **67c** and the bolt **68** is threaded into the intake cam shaft **60**, the link flange **67** is fixed to the intake cam shaft **60**. Additionally, the link flange **67** is fixed to the intake cam shaft **60** with the cam sprocket **53** interposed therebetween.

The engagement pin **67d** is attached to the circular portion **67a** at a position separated from the center in the radial direction. The engagement pin **67d** protrudes toward the intake cam shaft **60**. When the engagement pin **67d** engages with the engagement groove **60b** of the intake cam shaft **60**, the link flange **67** and the intake cam shaft **60** rotate together. The flange portion **67b** is provided with two engagement pins **67e** which protrude outward in the axial direction (rightward). The engagement pins **67e** engage with engagement grooves **71d** and **72d** of the first link member **71** and the second link member **72** to be described later.

As illustrated in FIG. **4**, the cam sprocket **53** is disposed between the sprocket flange **66** and the link flange **67** of the

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cam shaft 6. A circular hole 53a is formed at the center of the cam sprocket 53. Further, a side surface of the cam sprocket 53 is provided with two penetration holes 53b which serve as swing support points of the pair of link members 7. Two penetration holes 53b are disposed at positions facing each other with the circular hole 53a interposed therebetween.

Next, a configuration of the pair of link members 7 of the variable valve mechanism 100 according to the embodiment will be described with reference to FIG. 7. FIG. 7 is a side view of the variable valve mechanism 100 illustrated in FIG. 3. FIG. 7 illustrates the variable valve mechanism 100 illustrated in FIG. 3 from the right side. Further, for convenience of the description, the bolt 68 which fixes the link flange 67 to the intake cam shaft 60 is not illustrated in FIG. 7. FIG. 7 illustrates a state (a non-swing state) where the pair of link members 7 do not swing. The same applies to FIGS. 8 and 10 below.

As illustrated in FIG. 7, the pair of link members 7 include the first link member 71 and the second link member 72 which have the same configuration. The first link member 71 is disposed at the side opposite to the second link member 72 with the rotation axis of the cam sprocket 53 (the cam shaft 6) interposed therebetween. More specifically, the first link member 71 and the second link member 72 are disposed to be point-symmetrical to each other with respect to the center C of the rotation axis of the cam sprocket 53 and the cam shaft 6.

The first link member 71 is formed in a substantially crescent shape along the circumferential direction of the cam sprocket 53. The first link member 71 includes a support portion 71a which is supported by the cam sprocket 53 to be swingable (rotatable), a weight portion 71b which is formed to be separated from the support portion 71a, and an engagement portion 71c which engages with a part (the engagement pin 67e) of the link flange 67 (see FIG. 4). A locking hole 71e which locks one end of a first spring 74 to be described later is formed between the support portion 71a and the weight portion 71b. The locking hole 71e is disposed in the vicinity of a base end of the weight portion 71b. Further, a locking portion 71f which locks the other end of a second spring 75 to be described later is formed above the engagement portion 71c.

The support portion 71a is formed in a cylindrical shape through which the bolt 73 is insertable. The bolt 73 which is inserted through the support portion 71a and is fixed to the sprocket flange 66 through the cam sprocket 53 serves as a swing shaft of the first link member 71. The first link member 71 extends from the support portion 71a toward the front side in the rotation direction and a front end thereof is slightly bent inward in the radial direction. The bent front end portion is formed as the weight portion 71b. Further, the engagement portion 71c extends from the support portion 71a toward the rear side in the rotation direction and a rear end thereof is slightly located at the inside in the radial direction in relation to the support portion 71a. The rear end portion of the engagement portion 71c is provided with the engagement groove 71d which engages with the engagement pin 67e.

Similarly to the first link member 71, the second link member 72 is formed in a substantially crescent shape along the circumferential direction of the cam sprocket 53. The second link member 72 includes a support portion 72a which is supported by the cam sprocket 53 to be rotatable, a weight portion 72b which is formed to be separated from the support portion 72a, and an engagement portion 72c which engages with the link flange 67 (the engagement pin

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67e). A locking hole 72e which locks one end of the second spring 75 to be described later is formed between the support portion 72a and the weight portion 72b. The locking hole 72e is provided in the vicinity of a base end of the weight portion 72b. Further, a locking portion 72f which locks the other end of the first spring 74 to be described later is formed below the engagement portion 72c.

The support portion 72a has a cylindrical shape through which the bolt 73 is insertable. The bolt 73 which is inserted through the support portion 72a and is fixed to the sprocket flange 66 through the cam sprocket 53 serves as a swing shaft of the second link member 72. The second link member 72 extends backward in the rotation direction from the support portion 72a and a front end is slightly bent inward in the radial direction. The bent front end portion is formed as the weight portion 72b. Further, the engagement portion 72c slightly extends toward the front side in the rotation direction from the support portion 72a and a front end is slightly located at the inside of the radial direction in relation to the support portion 72a. The rear end portion of the engagement portion 72c is provided with the engagement groove 72d which engages with the engagement pin 67e.

The first link member 71 is attached to the cam sprocket 53 to be swingable when the bolt 73 is inserted through the penetration hole 53b of the cam sprocket 53 and the support portion 71a while the engagement pin 67e of the link flange 67 engages with the engagement groove 71d and the bolt 73 is threaded into the sprocket flange 66. Similarly, the second link member 72 is attached to the cam sprocket 53 to be swingable when the bolt 73 is inserted through the penetration hole 53b of the cam sprocket 53 and the support portion 72a while the engagement pin 67e of the link flange 67 engages with the engagement groove 72d and the bolt 73 is threaded into the sprocket flange 66.

Here, configurations of the engagement grooves 71d and 72d formed in the first link member 71 and the second link member 72 will be described with reference to FIG. 8. FIG. 8 is an enlarged view of the link member 7 (the first link member 71) of the variable valve mechanism 100 according to the embodiment. The engagement grooves 71d and 72d which are formed in the first link member 71 and the second link member 72 have the same configuration except for the direction. Here, a description will be made by using the engagement groove 71d of the first link member 71 and a description of the engagement groove 72d formed in the second link member 72 will be omitted.

As illustrated in FIG. 8, the engagement groove 71d has an elongated hole shape which extends in the radial direction of the cam sprocket 53 while the first link member 71 does not swing. The engagement groove 71d includes a first holding position 711 which holds the engagement pin 67e in a state where the first link member 71 does not swing to a predetermined position or more (in other words, a state where the first link member 71 is closed) and a second holding position 712 which holds the engagement pin 67e in a state where the first link member 71 swings to a predetermined position or more (in other words, a state where the first link member 71 is opened). The first holding position 711 and the second holding position 712 are substantially circular. The engagement groove 71d includes the first holding position 711 and the second holding position 712 formed at both ends thereof and these holding positions are connected to each other.

A first stopper portion 713a which protrudes toward the facing inner wall surface 714 of the engagement groove 71d in the vicinity of the first holding position 711 is provided at the inner wall surface 713 disposed at a farther side from the

bolt 73 in the inner wall surface of the engagement groove 71d. The first stopper portion 713a is used so that the engagement pin 67e received in the first holding position 711 does not easily move toward the second holding position 712. Meanwhile, a second stopper portion 714a which protrudes toward the facing inner wall surface 713 of the engagement groove 71d in the vicinity of the second holding position 712 is provided at the inner wall surface 714 disposed at a close side to the bolt 73 in the inner wall surface of the engagement groove 71d. The second stopper portion 714a is used so that the engagement pin 67e received in the second holding position 712 does not easily move toward the first holding position 711.

The engagement groove 71d is provided with a substantially S-shaped moving line ML in which the center of the engagement pin 67e bypasses the first stopper portion 713a and bypasses the second stopper portion 714a. That is, when the engagement pin 67e inside the engagement groove 71d moves from the first holding position 711 to the second holding position 712, the engagement pin reaches the second holding position 712 along a path in which the center moves away from the first stopper portion 713a and moves away from the second stopper portion 714a.

Further, the first link member 71 and the second link member 72 are provided with a pair of springs (the first spring 74 and the second spring 75) which respectively urge the weight portions 71b and 72b inward in the radial direction of the cam sprocket 53. For example, these springs are formed as compression coil springs. The first spring 74 is disposed at the side opposite to the second spring 75 with the rotation axis of the cam sprocket 53 (the cam shaft 6) interposed therebetween. More specifically, the first spring 74 and the second spring 75 are disposed to be point-symmetrical to each other with respect to the center C of the rotation axis of the cam sprocket 53 and the cam shaft 6.

One end (an upper end) of the first spring 74 is locked to the locking hole 71e at the side of the weight portion 71b of the first link member 71. Meanwhile, the other end (a lower end) of the first spring 74 is locked to the locking portion 72f at the side of the engagement portion 72c of the second link member 72. Further, one end (a lower end) of the second spring 75 is locked to the locking hole 72e at the side of the weight portion 72b of the second link member 72. Meanwhile, the other end (an upper end) of the second spring 75 is locked to the locking portion 71f at the side of the engagement portion 71c of the first link member 71. Both ends of the first spring 74 and the second spring 75 are locked by the first link member 71 and the second link member 72 so that an urging force of pulling both link members inward in the radial direction of the cam sprocket 53 is exerted.

Next, an operation of the variable valve mechanism 100 with such a configuration will be described with reference to FIGS. 9A and 9B. FIGS. 9A and 9B are diagrams illustrating an operation of the variable valve mechanism 100 according to the embodiment. FIG. 9A illustrates a state (a non-swing state: a closed state) where the pair of link members 7 do not swing and FIG. 9B illustrates a state (a swing state: an opened state) where the pair of link members 7 swing to maximum. Further, for convenience of the description, the bolt 68, the first spring 74, and the second spring 75 are not illustrated in FIGS. 9A and 9B.

In the variable valve mechanism 100, as illustrated in FIGS. 9A and 9B, the first link member 71 and the second link member 72 are urged inward in the radial direction of the cam sprocket 53 by the first spring 74 and the second spring 75. For example, when an engine rotation speed is a

predetermined rotation speed or less, centrifugal forces generated by the weight portions 71b and 72b are smaller than the urging forces of the first spring 74 and the second spring 75 as illustrated in FIG. 9A. For this reason, the first link member 71 and the second link member 72 do not swing about the support portions 71a and 72a as swing support points.

Further, the weight portions 71b and 72b are located at positions not protruding outward in the radial direction from the outer edge of the cam sprocket 53. At this time, the engagement pin 67e of the link flange 67 is received in the first holding position 711 at the inside of the engagement grooves 71d and 72d in the radial direction. In this case, the link flange 67 and the cam sprocket 53 rotate together without relative rotation. Accordingly, the intake cam shaft 60 and the exhaust cam shaft 61 (which are illustrated in FIG. 5) which engage with the link flange 67 also rotate together with the cam sprocket 53. As a result, in the valve train 5 (see FIG. 2), the opening and closing of the intake valve 50 and the exhaust valve 51 is controlled at a normal valve timing.

Meanwhile, when an engine rotation speed exceeds a predetermined rotation speed, the centrifugal forces generated by the weight portions 71b and 72b become larger than the urging forces of the first spring 74 and the second spring 75. For this reason, as illustrated in FIG. 9B, the first link member 71 and the second link member 72 swing about the bolt 73 inserted through the support portions 71a and 72a and the weight portions 71b and 72b move outward in the radial direction of the cam sprocket 53. Accordingly, the weight portions 71b and 72b are located at positions protruding outward in the radial direction from the outer edge of the cam sprocket 53.

Further, when the first link member 71 and the second link member 72 swing, the engagement portions 71c and 72c move inward in the radial direction. Accordingly, the link flange 67 rotates in the opposite direction relatively to the cam sprocket 53 while the engagement pin 67e is received in the second holding position 712 at the outside of the radial direction of the engagement grooves 71d and 72d. Accordingly, the intake side cam shaft 60 which engages with the link flange 67 rotates relatively to the cam sprocket 53. As a result, the opening/closing timing of the intake valve 50 is adjusted. In this way, in the variable valve mechanism 100, when the first link member 71 and the second link member 72 are swung in response to the engine rotation speed so that the intake side cam shaft 60 (the link flange 67) and the cam sprocket 53 rotate relatively to each other, the opening/closing timing of the intake valve 50 can be changed.

In this way, in the variable valve mechanism 100 according to the embodiment, the first link member 71 and the second link member 72 swing to the outside of the cam sprocket 53 in the radial direction under a predetermined condition so that the intake side cam shaft 60 (the link flange 67) rotates relatively to the cam sprocket 53. For this reason, the phase in the rotation direction of the intake side cam shaft 60 can be changed in response to the swing operation of the link member 7 (the first link member 71 and the second link member 72). Accordingly, an operating resistance can be suppressed to be low compared to a known configuration in which the centrifugal weight is sandwiched between the pair of driven members. As a result, the phase of the cam shaft 6 in the rotation direction can be smoothly changed.

Further, the first link member 71 includes the bolt 73 which is fixed to the cam sprocket 53 and serves as a swing shaft, the weight portion 71b which is disposed to be

separated from the bolt 73, and the engagement portion 71c which engages with the engagement pin 67e provided at the cam shaft 6 and transmits the rotation of the cam sprocket 53 to the cam shaft 6 and is supported by the cam sprocket 53 to be swingable. Here, in accordance with the rotation of the cam sprocket 53, the weight portion 71b moves outward in the radial direction of the cam sprocket 53 and the engagement portion 71c moves to move the engagement pin 67e, thereby relatively rotating the intake side cam shaft 60. The same applies to the second link member 72. Accordingly, the intake side cam shaft 60 can be rotated relatively when the first link member 71 and the second link member 72 swung by the centrifugal force generated in accordance with the rotation of the cam sprocket 53 (in response to a change in rotation speed). For this reason, it is possible to smoothly change the phase in the rotation direction of the cam shaft 6 with a simple configuration without requiring a particular control mechanism for relatively rotating the intake side cam shaft 60.

Further, since the first link member 71 and the second link member 72 are swung by the centrifugal force generated by the rotation of the cam sprocket 53, a friction force of the bolt 73 can be reduced. For this reason, the weight portions 71b and 72b can be moved even when a change in torque of the engine 2 does not occur. As a result, it is possible to easily perform an inspection or an operation check of the cam shaft 6.

Further, in the variable valve mechanism 100 according to the embodiment, the first link member 71 and the second link member 72 are disposed at the opposite side with the rotation axis of the cam sprocket 53 interposed therebetween and the first spring 74 and the second spring 75 are disposed at the opposite side with the rotation axis of the cam sprocket 53 interposed therebetween. Accordingly, the first link member 71 and the second link member 72 can be disposed with a good balance along with the first spring 74 and the second spring 75. For this reason, the rotation of the cam shaft 6 can be smoothly kept without a weight portion for ensuring a balance.

In particular, the first link member 71 and the second link member 72 are disposed to be point-symmetrical to each other with respect to the center C of the rotation axis of the cam sprocket 53. For this reason, a rotation force generated from the cam sprocket 53 can be symmetrically transmitted to the cam shaft 6 through the link members 7. Accordingly, the rotation of the cam shaft 6 can be smoothly performed. Further, the rotation of the cam shaft 6 can be smoothly kept without a weight portion for ensuring a balance.

Further, the engagement grooves 71d and 72d are provided at the engagement portions 71c and 72c of the first link member 71 and the second link member 72. The first holding position 711 and the second holding position 712 are respectively provided in the engagement grooves 71d and 72d and the first stopper portion 713a which protrudes toward the facing inner wall surface 714 is provided in the inner wall surface 713 disposed at a farther side from the bolt 73 in the inner wall surfaces of the engagement grooves 71d and 72d. For this reason, the engagement pin 67e received in the first holding position 711 cannot move easily. Accordingly, even when a driving reaction force which is given from the intake valve 50 (the exhaust valve 51) to the intake cam 62 (the exhaust cam 63) is transmitted to the first link member 71 and the second link member 72 through the cam shaft 6 and the engagement portions 71c and 72c, the vibration of the first link member 71 and the second link member 72 can be suppressed.

Similarly, the second stopper portion 714a which protrudes toward the facing inner wall surface 713 is provided in the inner wall surface 714 disposed at a close side from the bolt 73 in the inner wall surfaces of the engagement grooves 71d and 72d. For this reason, the engagement pin 67e received in the second holding position 712 cannot move easily. Accordingly, even when a driving reaction force given from the intake valve 50 (the exhaust valve 51) to the intake cam 62 (the exhaust cam 63) is transmitted to the first link member 71 and the second link member 72 through the cam shaft 6 and the engagement portions 71c and 72c, the vibration of the first link member 71 and the second link member 72 can be suppressed.

Further, the engagement grooves 71d and 72d are provided with a substantially S-shaped moving line in which the center of the engagement pin 67e bypasses the first stopper portion 713a and bypasses the second stopper portion 714a. For this reason, it is possible to prevent the engagement pin 67e received in the first holding position 711 or the second holding position 712 from moving easily compared to a case where the moving line of the engagement pin 67e is linear. Accordingly, the first link member 71 and the second link member 72 can be swung and the first link member 71 and the second link member 72 can be returned to the non-swing state at a desired timing.

Here, a positional relation of the components of the link member 7 of the variable valve mechanism 100 according to the embodiment will be described with reference to FIG. 10. FIG. 10 is a diagram illustrating a positional relation of components of the link member 7 of the variable valve mechanism 100 according to the embodiment. The components of the first link member 71 and the components of the second link member 72 have the same positional relation. In the following description, a description will be made by using the first link member 71 and a detailed description of the second link member 72 will be omitted. Additionally, for convenience of the description, the second spring 75 is not illustrated in FIG. 10.

As illustrated in FIG. 10, the first link member 71 is formed so that a distance L1 of an imaginary line LA connecting a center C1 of the bolt 73 forming a swing shaft to a center C2 of the engagement pin 67e received in the first holding position 711 in the non-swing state is smaller than a distance L2 of an imaginary line LB connecting the center C1 of the bolt 73 and a locking position C3 of the first spring 74 with respect to the locking hole 71e.

In this way, since the distance L1 between the bolt 73 and the engagement pin 67e is set to be smaller than the distance L2 between the bolt 73 and the first spring 74, a rotation moment Ma for swinging the first link member 71 can be suppressed to be small when a driving reaction force given from the intake valve 50 (the exhaust valve 51) to the intake cam 62 (the exhaust cam 63) is transmitted to the first link member 71 through the cam shaft 6, the engagement pin 67e, and the engagement portion 71c. Accordingly, it is possible to prevent a problem in which the first link member 71 easily swings.

Here, a direction of the driving reaction force transmitted from the engagement pin 67e to the first link member 71 becomes a direction of a tangential line TL between a concentric circle and the cam shaft 6 passing through the center C2 of the engagement pin 67e. Here, the rotation moment Ma is obtained by the following equation when a force given from the engagement pin 67e by the driving reaction force is denoted by "F" and an angle formed by the imaginary line LA connecting the center C1 of the bolt 73 and the center C2 of the engagement pin 67e in the non-

swing state and the tangential line TL of the circle indicated by the dashed line, passing through the center C2 of the engagement pin 67e, and using the rotation axis of the cam shaft 6 (the cam sprocket 53) as the center C is denoted by “α”.

$$\text{Rotation moment } Ma = F \sin \alpha \cdot L1$$

Further, the first link member 71 is formed so that the angle α is smaller than an angle β formed by the imaginary line LB connecting the center C1 of the bolt 73 and the locking position C3 of the first spring 74 and the center line LC of the first spring 74.

In this way, since the angle α is set to be smaller than the angle β, the rotation moment Ma for swinging the first link member 71 can be suppressed to be smaller than the rotation moment Mb for pressing the first link member 71 by the first spring 74 and the second spring 75 when the driving reaction force given from the intake valve 50 (the exhaust valve 51) to the intake cam 62 (the exhaust cam 63) is transmitted to the first link member 71 through the cam shaft 6 and the engagement portion 71c. Accordingly, it is possible to prevent a problem in which the first link member 71 easily swings. Here, the rotation moment Mb is obtained by the following equation when the spring constants of the first spring 74 and the second spring 75 are denoted by “K” and the expansion lengths of the first spring 74 and the second spring 75 are denoted by “x”.

$$\text{Rotation moment } Mb = K \cdot x \sin \beta \cdot L2$$

Further, the first link member 71 is disposed so that the imaginary line LA connecting the center C1 of the bolt 73 and the center C2 of the engagement pin 67e in the non-swing state intersects at a right angle to the imaginary line LD connecting the center C of the rotation axis of the cam shaft 6 (the cam sprocket 53) and the center 02 of the engagement pin 67e.

Accordingly, the bolt 73 is disposed in the vicinity of the movement direction accompanied by the rotation of the cam shaft 6, that is, the tangential direction in the non-swing state. For this reason, even when the driving reaction force given from the intake valve 50 (the exhaust valve 51) to the intake cam 62 (the exhaust cam 63) is transmitted to the first link member 71 through the cam shaft 6, the engagement pin 67e, and the engagement portion 71c, the direction of the driving reaction force substantially overlaps the imaginary line LA. Accordingly, since the angle α becomes very small, the rotation moment Ma for swinging the first link member 71 can be suppressed to minimum and thus an unexpected swing of the first link member 71 can be effectively suppressed.

Further, the first link member 71 is disposed so that the angle β including the rotation axis of the cam sprocket 53 among the angles formed by the imaginary line LB connecting the center C1 of the bolt 73 and the locking position C3 of the first spring 74 and the center line LC of the first spring 74 in the non-swing state becomes an acute angle.

In this way, since the angle β which is narrowed in accordance with an increase in swing angle of the first link member 71 is set to an acute angle in advance, the rotation radius of the weight portion 71b can be increased in accordance with an increase in swing angle of the first link member 71 and thus the centrifugal force of the weight portion 71b can be increased in proportional to the rotation radius. Accordingly, since the urging force increases as the swing angle of the first link member 71 increases in accordance with an increase in rotation speed of the cam sprocket 53, the first link member 71 can be immediately operated.

Meanwhile, the first link member 71 can be returned to the non-swing state in accordance with a decrease in rotation speed of the cam sprocket 53. As a result, it is possible to improve the responsiveness of the operation of the first link member 71 in response to the rotation speed of the cam sprocket 53.

Further, the distance L2 between the center C1 of the bolt 73 of the first link member 71 and the locking position C3 of the first spring 74 with respect to the locking hole 71e of the first link member 71 is set to be larger than a distance L3 of an imaginary line LF connecting a center C5 of the bolt 73 of the second link member 72 and a locking position C4 of the first spring 74 with respect to the locking portion 72f of the second link member 72. Further, a distance L4 between the center C5 of the bolt 73 of the second link member 72 and a locking position C6 of the second spring 75 with respect to the locking hole 72e of the second link member 72 is set to be larger than a distance L6 between the center C1 of the bolt 73 of the first link member 71 and the locking position C7 of the second spring 75 with respect to the locking portion 71f of the first link member 71.

Accordingly, even in a structure of pulling the weight portions 71b and 72b and the engagement portions 71c and 72c of the first link member 71 and the second link member 72, the rotation moment Mc of the weight portions 71b and 72b becomes larger than the rotation moment Md of the engagement portions 71c and 72c and thus the first link member 71 and the second link member 72 thereof can be urged in the non-swing direction. Accordingly, even when the locking positions of the first spring 74 and the second spring 75 are provided at the weight portions 71b and 72b and the engagement portions 71c and 72c in a narrow space, the phase in the rotation direction of the cam shaft 6 can be stably changed.

Here, the rotation moment Mc is expressed by the following equation when the spring constants of the first spring 74 and the second spring 75 are denoted by “K” and the expansion lengths of the first spring 74 and the second spring 75 are denoted by “x”. Further, the rotation moment Md is obtained by the following equation when the spring constants of the first spring 74 and the second spring 75 are denoted by “K”, the expansion lengths of the first spring 74 and the second spring 75 are denoted by “x”, and the angle between the center line LC and the imaginary line LF is denoted by “r”.

$$\text{Rotation moment } Mc = K \cdot x \sin \beta \cdot L2$$

$$\text{Rotation moment } Md = K \cdot x \sin \gamma \cdot L3$$

Regarding the first link member 71 and the second link member 72, the weight portions 71b and 72b are disposed at one side and the engagement portions 71c and 72c are disposed at the other side in an imaginary line LE connecting the center C1 of the bolt 73 and the center C of the rotation axis of the cam sprocket 53. Then, one end of the first spring 74 is locked to the locking hole 71e at the side of the weight portion 71b of the first link member 71 and the other end thereof is locked to the locking portion 72f at the side of the engagement portion 72c of the second link member 72. Meanwhile, one end of the second spring 75 is locked to the locking hole 72e at the side of the weight portion 72b of the second link member 72 and the other end thereof is locked to the locking portion 71f at the side of the engagement portion 71c of the first link member 71.

That is, both the first spring 74 and the second spring 75 are respectively locked to the first link member 71 and the second link member 72. For this reason, when one ends

(ends on the side of the weight portions **71b** and **72b**) of the first spring **74** and the second spring **75** are pulled outward in the radial direction of the cam sprocket **53**, the other ends (ends on the side of the engagement portions **72c** and **71c**) of the second spring **75** and the first spring **74** move inward in the radial direction of the cam sprocket **53**. Accordingly, since the expansion/contraction amounts of the first spring **74** and the second spring **75** can be decreased, a burden on the springs can be reduced.

Further, since both ends of the first spring **74** and the second spring **75** are locked to the first link member **71** and the second link member **72**, the first spring **74** and the second spring **75** are operated at the same time when the first link member **71** and the second link member **72** swing. For this reason, the first spring **74** and the second spring **75** do not interfere with each other. Accordingly, since the first link member **71** and the second link member **72** can be disposed at a close position, the variable valve mechanism **100** can have a simple and compact structure.

Additionally, the invention is not limited to the above-described embodiment and can be modified into various forms. In the above-described embodiment, the sizes or the shapes illustrated in the accompanying drawings are not limited thereto and can be appropriately changed without departing from the effect of the invention. In addition, an appropriately modification can be made without departing from the object of the invention.

For example, in the above-described embodiment, a case has been described in which the pair of link members **7** (the first link member **71** and the second link member **72**) are provided and the pair of first springs **74** and the second spring **75** are provided, but the invention is not limited to this configuration. For example, the number of link members or springs may be one or three or more on the condition that the phase of the rotation direction of the intake cam shaft **60** can be changed in accordance with the rotation of the cam sprocket **53**.

Further, in the above-described embodiment, a case has been described in which the first link member **71** and the second link member **72** are disposed to be point-symmetrical to each other with respect to the center **C** of the rotation axis of the cam sprocket **53**, but the invention is not limited to this configuration. The first link member **71** and the second link member **72** can be disposed at arbitrary positions on the condition that the phase of the rotation direction of the intake cam shaft **60** can be changed in accordance with the rotation of the cam sprocket **53**.

Further, in the above-described embodiment, the single cylinder engine **2** has been exemplified, but the invention is not limited to this configuration. For example, the valve train **5** (the variable valve mechanism **100**) according to the embodiment may be also applied to a multi-cylinder engine.

Further, in the above-described embodiment, the single cylinder engine has a so-called four valve type valve train in which each of the intake valve **50** and the exhaust valve **51** is provided at two positions so that four valves are provided in total, but the invention is not limited to this configuration. The number of the intake valves **50** and the exhaust valves **51** can be appropriately changed.

Further, in the above-described embodiment, a case in which the variable valve mechanism **100** is applied to the SOHC type valve train **5** has been described, but the invention is not limited to this configuration. For example, the variable valve mechanism **100** may be also applied to a double overhead camshaft (DOHC) type valve train.

Further, in the above-described embodiment, a configuration has been described in which one of engagement

portions is formed as an engagement pin and the other thereof is formed as an engagement hole or a groove, but the invention is not limited to this configuration. For example, one of the engagement portions may be formed as an engagement hole or a groove and the other thereof may be formed as a protrusion such as an engagement pin.

Further, in the above-described embodiment, the variable valve mechanism **100** is used to adjust the opening/closing timing of the intake valve **50**, but the invention is not limited to this configuration. The variable valve mechanism **100** may be used to adjust the opening/closing timing of the exhaust valve **51**.

Further, in the above-described embodiment, a predetermined centrifugal force (an engine rotation speed) during the operation of the variable valve mechanism **100** (when the first link member **71** and the second link member **72** swing) can be appropriately changed in response to a desired valve timing.

INDUSTRIAL APPLICABILITY

As described above, the invention has an effect that a phase of a rotation direction of a cam shaft can be stably changed and is particularly useful for a variable valve mechanism applicable to a single overhead camshaft (SOHC) type valve train, an engine, and an automatic two-wheeled vehicle.

REFERENCE SIGNS LIST

- 1** automatic two-wheeled vehicle
- 2** engine
- 5** valve train
- 50** intake valve
- 51** exhaust valve
- 53** cam sprocket
- 6** cam shaft
- 60** intake cam shaft
- 61** exhaust cam shaft
- 62** intake cam (intake side cam)
- 63** exhaust cam (exhaust side cam)
- 66** sprocket flange
- 67** link flange
- 100** variable valve mechanism
- 7** link member
- 71** first link member
- 71a, 72a** support portion
- 71b, 72b** weight portion
- 71c, 72c** engagement portion
- 71d, 72d** engagement groove (groove)
- 711** first holding position
- 712** second holding position
- 713a** first stopper portion
- 714a** second stopper portion
- 72** second link member
- 73** bolt (swing shaft)
- 74** first spring (first urging member)
- 75** second spring (second urging member)

What is claimed is:

1. A variable valve mechanism which changes an opening/closing timing of an intake valve or an exhaust valve in response to an engine rotation speed, the variable valve mechanism comprising:
 - a cam sprocket which rotates in response to a rotation of a crank shaft;

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a cam shaft which is integrated with any one of intake side and exhaust side cams and is provided to be rotatable relatively to the cam sprocket; and
 a link member that engages with the cam sprocket and the cam shaft and transmits a rotation from the cam sprocket to the cam shaft, wherein
 the link member is supported by the cam sprocket to be swingable and swings in response to a change in rotation speed of the cam sprocket to rotate the cam shaft relatively to the cam sprocket,
 the link member includes:
 a swing shaft which is fixed to the cam sprocket;
 a weight portion which is disposed to be separated from the swing shaft; and
 an engagement portion which engages with an engagement pin provided in the cam shaft and transmits a rotation of the cam sprocket to the cam shaft;
 the link member is supported by the cam sprocket to be swingable; and
 the weight portion moves outward in a radial direction of the cam sprocket and the engagement portion moves to move the engagement pin in accordance with the rotation of the cam sprocket so that the cam shaft rotates relatively to the cam sprocket;
 the engagement portion is formed as a groove having an inner wall surface, and
 the groove is provided with a first holding position which receives the engagement pin while the link member does not swing to a predetermined position or more and a second holding position which receives the engagement pin while the link member swings to a predetermined position or more,
 a first stopper portion is provided in the inner wall surface disposed at a farther side from the swing shaft in a vicinity of the first holding position, and
 the first stopper portion protrudes toward the inner wall surface facing the first stopper portion.

2. The variable valve mechanism according to claim 1, further comprising:
 a spring that is locked to the link member and urges the weight portion inward in the radial direction of the cam sprocket, wherein
 in a non-swing state of the link member, a distance of an imaginary line connecting a center of the swing shaft and a center of the engagement pin is smaller than a distance of an imaginary line connecting the center of the swing shaft to a locking position of the spring on the link member.

3. The variable valve mechanism according to claim 2, wherein
 in the non-swing state of the link member, an angle α formed by the imaginary line connecting the center of the swing shaft and the center of the engagement pin and a tangential line of a circle using a rotation axis of the cam shaft as a center and passing through the center of the engagement pin is smaller than an angle β formed by a center line of the spring and the imaginary line connecting the center of the swing shaft and the locking position of the spring.

4. The variable valve mechanism according to claim 2, wherein
 the spring is disposed so that one end of the spring is locked to a position near the weight portion in relation to the swing shaft,

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an angle β formed by a center line of the spring and an imaginary line passing through the locking position of the spring and the center of the swing shaft is an acute angle, and
 the imaginary line and the center line forming the angle β interpose a rotation axis of the cam sprocket.

5. The variable valve mechanism according to claim 2, wherein
 the link member is a first link member and the variable valve mechanism further includes an identical second link member,
 the first link member is disposed at one side of a rotation axis of the cam sprocket and the second link member is disposed at another side of the rotation axis of the cam sprocket so that the first link member and the second link member interpose the rotation axis of the cam sprocket,
 the spring is a first spring and the variable valve mechanism further includes an identical second spring
 the first spring is disposed at one side of the rotation axis of the cam sprocket and the second spring is disposed at another side of the rotation axis of the cam sprocket so that the first spring and the second spring interpose the rotation axis of the cam sprocket.

6. The variable valve mechanism according to claim 5, wherein
 the first link member and the second link member are disposed to be point-symmetrical to each other with respect to a center of the rotation axis of the cam sprocket and the first spring and the second spring are disposed to be point-symmetrical to each other with respect to the center of the rotation axis of the cam sprocket.

7. The variable valve mechanism according to claim 5, wherein
 in the first link member and the second link member, the weight portion is disposed at one side and the engagement portion is disposed at another side with respect to an imaginary line connecting the center of the swing shaft and the center of the rotation axis of the cam sprocket;
 one end of the first spring is locked to a position near the weight portion in relation to the swing shaft of the first link member and another end of the first spring is locked to a position near the engagement portion in relation to the swing shaft of the second link member;
 and
 one end of the second spring is locked to a position near the weight portion in relation to the swing shaft of the second link member and another end of the second spring is locked to a position near the engagement portion in relation to the swing shaft of the first link member.

8. The variable valve mechanism according to claim 7, wherein
 a distance between a locking position of the first spring at the position near the weight portion in the first link member and the center of the swing shaft of the first link member is larger than a distance between the locking position of the first spring at the position near of the engagement portion in the second link member and the center of the swing shaft of the second link member; and
 a distance between a locking position of the second spring at the position near the weight portion in the second link member and the center of the swing shaft of the second link member is larger than a distance between

the locking position of the second spring at the position near the engagement portion in the first link member and the center of the swing shaft of the first link member.

9. The variable valve mechanism according to claim **1**,
wherein

in a non-swing state of the link member, an imaginary line connecting a center of the swing shaft to a center of the engagement pin intersects at a substantially right angle to an imaginary line connecting a center of a rotation axis of the cam shaft and the center of the engagement pin.

10. The variable valve mechanism according to claim **1**,
wherein

a second stopper portion is provided in the inner wall surface disposed at a close side to the swing shaft in a vicinity of the second holding position, and the second stopper portion protrudes toward the inner wall surface facing the second stopper portion .

11. The variable valve mechanism according to claim **10**,
wherein the groove is provided with a substantially S-shaped moving line in which a center of the engagement pin in a front view bypasses the first stopper portion and the second stopper portion.

12. An engine comprising:
the variable valve mechanism according to claim **1**.

13. An automatic two-wheeled vehicle comprising:
the engine according to claim **12**.

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